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Introduction and Summary

All potential improvement options itemized in the North Fork Flathead Road Corridor Study Draft Document (Draft Study) that was published for public review July 15, 2010 were reviewed and considered by study team members. The potential improvement options were also reviewed by resource agencies in early July 2010. The options were collated into categories based on similarity. The categories that are shown in the Draft Study include *No-Build*, *Maintenance Treatments*, *Stabilization Treatment*, *Improve Gravel Surfacing*, *Speed Enforcement/Reduction Strategies*, and *Bituminous Surface Treatment/Asphalt Concrete Pavement*.

Each option is described below and further information and materials related to analysis completed by the study engineer and team are located in the North Fork Flathead Road Improvement Options Technical Report working files. This report includes vendor specific information for materials and treatments described in this Appendix, as well as calculations used for cost estimates. The No-Build option (Option 1) in the main North Fork Flathead Road Corridor Study Draft Document is discussed in detail and therefore, not outlined in this Appendix.

During this Corridor Study improvement option analysis process, the combination or incremental implementation of the options was not considered, due to the time constraints of this process. However, it is reasonable to consider that some of the improvement options could be combined and implemented simultaneously or incrementally.

Maintenance Treatments

Improvement Option 2a – Additional Grading

This option is proposed to reduce the quantity and severity of potholes and wash boarding. Grading would be performed four times per year, twice as often as currently performed. The width of the roadway just north of the end of pavement (approximately RP 12.4) requires additional passes by the grading equipment and the cost for grading varies year to year, based on many variables. These variables include, but are not limited to, increased snow and/or rainfall, fire events, minor flooding from the perennial streams and creeks onto the roadway.

Because currently only two grading events are completed each year, funded by Flathead County, it is unknown to what extent the wash boarding and pothole severity could be reduced by additional grading events.

Improvement Option 2b – Guardrail

The existing guardrail has been impacted by fire, plowing, and collisions in various locations. No reported crashes have been specifically documented as related to guardrail failures along this road.

Existing guardrail locations were analyzed and there are no locations in the study area that are lacking appropriate guardrail installations.

Stabilization Treatments

Any stabilization and dust control treatments would be implemented in conjunction with existing grading maintenance for maximum effectiveness. Stabilization treatments are types of additives which are used to “stabilize” the roadway by application or incorporating the additive in the surface gravel of the roadway to bind dust particles to create a more solid or durable driving

surface. These treatments would only be eligible for federal funding if implemented in conjunction with new crushed surface. Otherwise, the treatments are considered maintenance and are not eligible for federal funding.

According to information from the USFS, dust suppressants work by either agglomerating the fine particles, adhering/binding the surface particles together, or increasing the density of the road surface material. The suppressants reduce the ability of the surface particles to be lifted and suspended by vehicle tires or wind. To select the appropriate palliative, one must understand the primary factors that generate dust. They include the following:

- Vehicle speed
- Number of wheels per vehicle
- Number of vehicles
- Vehicle weight
- Particle size distribution (gradation) of the surface material
- Restraint of the surface fines (compaction, cohesiveness/bonding, durability)
- Surface moisture (humidity, amount of precipitation, amount of evaporation).

Improvement Option 3a - Bentonite

This treatment comes from naturally occurring clay which binds to the dust particles in gravel roads to reduce dust. It works best with limestone type gravels. The most effective dust reduction occurs when bentonite is added to the roadway aggregate when placed, rather than used only as a yearly application on the surface of the roadway. In other words, this improvement option would require a new gravel lift to be placed at the same time as the bentonite application.

According to Technology News, an Iowa State University Transportation Center publication, a benefit of bentonite is its environmental friendliness. Iowans are increasingly concerned about possible environmental damage associated with chemical dust-control materials such as calcium chloride.

An Iowa State professor, Ken Bergeson, says that bentonite is a naturally occurring mineral containing no salt and poses no danger to the environment, and it does not contribute to vehicle rusting, as calcium chloride does. Additional information is available in this appendix, beginning on page 115.

Improvement Option 3b - Magnesium Chloride/Calcium Chloride (MgCl/CaCl)

MgCl is the chemical most commonly used by Flathead County and MDT for dust suppression is placed once a year in the springtime during road grading. *Calcium chloride (CaCl)* is not used often in Montana, but is very similar to MgCl in many aspects. Calcium and magnesium chloride can be very effective if used properly. They are hygroscopic products which, in simplest terms, mean they draw moisture from the air and keep the road surface constantly damp. Additional these chemicals are reasonably simple to use.

Magnesium chloride is a naturally occurring element that is extracted from saltwater solutions, such as those found in sea water. For detailed information that is part of the Environmental Protection Agency' gravel roads maintenance and design manual, please see page 110.

"Calcium chloride absorbs water vapor from the air and liquid water from the road bed...keeping the moisture in the road," according to usroads.com. But compared with lignosulfonate and magnesium chloride, calcium chloride does not perform as well in the areas of reducing dust, reducing the loss of road aggregate, and lowering maintenance costs of unpaved roads. This

information can be found in a Colorado State University study at www.buysalt.com/magchloride/dustgard/studyeffectiveness.htm

Details of one manufacturer's case study on Calcium Chloride are located in this appendix (page 106).

Improvement Option 3c - Lignin

This treatment consists of a polymer derived from wood and can be used to suppress dust by spraying on top, or mixed with the top few inches of road surface to stabilize and thus reduce dust. These are products available under various commercial names. The basic composition is lignin sulfonate which is a by-product of the pulp milling industry. The product is sometimes called "treesap" in the field. These products work best when incorporated into the surface gravel. They then provide cohesion to bind the soil particles together. Manufacturers of the lignin products claim these as neutral to the environment.

Lignin has been used for 60 years to control dust and stabilize gravel on unpaved roads. For dust control, spray application is the method to apply it onto the roadway surface. For stabilization and dust control, it is better to mix it with the top few inches of road surface. It is water soluble, considered to be environmentally friendly, easy to handle and apply, and very cost-effective.

The benefits include increased load-bearing capacity (similar to a 3-inch layer of asphalt concrete), a firmer road surface without loose gravel, dust abatement, reduced frost-heave damage, and cost-savings in both construction and maintenance. The surface will still develop potholes, and the use of grading to scrape off and remix the top layer after a few months will be needed but maintenance procedures can be significantly reduced.

Local cost information is not available.

Improvement Option 3d - Black Oil

Black oil is an asphalt emulsion. Normally, a suspension made up of small drops of one liquid with another liquid will not mix. If a suspension is properly mixed, either by mechanical agitation or by chemical processes, an emulsion forms. Unstable emulsions will separate with time or temperature. Stable emulsions will not separate. Because an emulsion is a dispersion of one immiscible phase in another, an asphalt emulsion is asphalt dispersed in water. This is not a solution, because the two phases (oil in water) are susceptible to separation. So, like a good salad dressing, the oil is stabilized with an emulsifier to keep it dispersed.

Emulsions allow the formation of an asphalt binder with low enough viscosity for easy application. The dispersion in water gives the surface many of the properties of water such as low viscosity, lower temperature requirements for both application and storage, and less sensitivity to application on damp surfaces.

This treatment applied to gravel roadways does not last as long as MgCl, and price varies greatly with asphalt prices. In 2009, Flathead County estimated it would cost \$4,000-8,000 per mile to apply. In 2010, Montana Dust Control Company estimated that it was roughly the same cost to apply as MgCl or another similar chemical.

Further information in regards to asphalt emulsions can be located at http://fhwapap34.fhwa.dot.gov/NHI-PPTCG/chapter_2/index.htm

Improvement Option 3e – EnvironKleen

This improvement option would consist of the application of the trademarked product EnvironKleen. This treatment is made of a polymer or resin binder used to stabilize the road surface. It binds dust particles to prevent them from escaping, and can be used in any temperature. This treatment is three times more expensive than the other stabilization treatment options. Detailed information about this product can be found later in this appendix, beginning on page 69.

Improvement Option 3f – RoadOyl

RoadOyl is a resin-modified emulsion that provides a cold applied high performance treatment for bare earth or unpaved surfaces such as stockpiles, or as road dust control for unpaved roads. It is formulated from tree resin ingredients, and is a non-ionic emulsion technology unique in its high bonding strength. It is claimed as appropriate for use even in close proximity to wetland areas and other areas of environmental sensitivity. RoadOyl may provide clean, high performance technology needed for surface dust control and soil stabilization.

This improvement option would be an application of the treatment made from a pine resin emulsion that is used to stabilize the road surface. Road Oyl is a natural flexible pavement binder emulsion formulated from pine rosin (the solid form of pine resin) and pitch in water. The pitch and rosin, which comprise roughly fifty percent of Road Oyl by weight, are co-produced with other timber products from southern pine in the southeastern United States.

Roadway traffic on this treatment will help to compact the surface into a smooth pavement-like finish. RoadOyl can react with strong organic oxidizing materials, strong acids and strong bases. RoadOyl slightly darkens the aggregate or soil that it is applied to. It is best used where there are numerous rocks in the roadway material, but not as much fines material, as this allows the RoadOyl and roadway material to bind the road surface together.

Because this is a trademarked name brand product, the majority of information analyzed by the study team about the product is shown at the manufacturer's website. Basic information on RoadOyl can also be found in the dust control product section, beginning on page 82 of this appendix.

Improvement Option 3g – SoilSement

SoilSement is a manufactured acrylic polymer emulsion used to stabilize the road surface. It is applied as a diluted solution, with residual benefits each year. Applications are designed to last 3 to 6 months. SoilSement is categorized as environmentally safe, non-toxic, non-corrosive, non-flammable and does not pollute groundwater. The product dries clear, and is said to weather better than RoadOyl. This information was provided during discussions with representatives from companies that provide these materials to Flathead County and other entities within Montana and neighboring states. This product is best used anywhere there are a lot of fines to bind the road material together.

Because this is a trademarked name brand product, the majority of information analyzed by the study team about the product is shown at the manufacturer's website. Basic information on SoilSement can also be found in the dust control product section, beginning on page 86 of this appendix.

Improvement Option 3h – Dead Wood and Vegetable Oil

This treatment was suggested as a possible use of the dead wood, mostly resulting from recent fires along NFFR, combined with vegetable oils, due to the low cost of both potential

ingredients. This option was removed from further analysis as a possible improvement option because it is not a tested road treatment.

Improvement Option 3i - Soybean Oil Byproduct

This method has been used with success in Minnesota. While a single application is more expensive than calcium chloride, the treatment lasts an entire summer and uses sustainable sources. The environmentally friendly product degrades in approximately 28 days. During the analysis of this improvement option conflicting information was received about the applicability to dust control on roadways. Due to concern regarding the possibility of wildlife being attracted to this product, the team determined that this option should be excluded from further consideration.

Improve Gravel Surfacing

Improvement Option 4a -New Gravel Lift

A new 26 foot wide gravel lift would be placed to a depth of six inches. This option would improve the roadway surface conditions, such as potholing and wash boarding. The cost estimate for this option includes maintenance of the new lift, as well as grading twice a year on the normal county maintenance schedule.

Improvement Option 4b - Double shot/bitumen

Two chip seals would be applied on top of the gravel road, sealing the top to both reduce dust and improve the roadway surface conditions. This option includes the recommendation to reconstruct the gravel base prior to the first application, grade, and eliminate any soft spots, poor gravel, or other conditions that would reduce the life of the treatment. If the gravel corridor is inspected and determined to be in sufficiently good condition, the treatment would cost considerably less. Double Shot (two chip seals) would be reapplied every five years.

Improvement Option 4c - Driving Surface Aggregate (DSA)

DSA is an all-rock gravel which has been used with success by Western Federal Lands in Lava Beds National Monument, California. Pros include reduced maintenance cycles, no chemicals and reduced dust. Maintenance includes grading about half as often as a typical gravel road. A pre-paver depth of eight inches is compacted to either a four and one half or six inch surface. Surface life is extended with greater compacted depth. Compared to other gravel roads, DSA produces considerably less dust. However, dust control treatments can still be applied if desired. Information about DSA is included in this appendix, beginning on page 56.

Speed Enforcement/Reduction Strategies

Improvement Option 5a -Speed Indicator Signs (Solar)

These signs detect and display a vehicle's current speed and flash or give some other indication when the roadway user has exceeded the speed limit. If this option were selected, analysis would need to be completed in order to determine optimal locations for the signs. The Flathead County Roads and Bridges Department and MDT could assist in determining where these signs might be placed and maybe a number of signs. The average lifespan of a solar sign is ten to 15 years. The signs are mountable on a standard or existing sign post, or are available in a portable trailer version. Information about the set up and programming of these signs can be found at: <http://www.mega-tech.com/html/prod-speedsentry.html>

Improvement Option 5b - Speed Dips/Speed Humps

Speed humps, mounded traffic calming or slowing structures that extend the width of the travelway in a road, were removed from consideration early in the improvement options analysis due to difficulty for snow removal. Speed bumps (or humps) and dips are often grouped together and referred to interchangeably.

Speed dips, built as concave ditch like structures across the travel way of the road, would have to be heavily justified for funding to be found for them. Based on Flathead County policy, speed dips were also removed from consideration because they impede maintenance on gravel roads, particularly grading.

Information was located for installation of speed bumps that can accommodate snow plows if it is desirable to pursue this improvement option in the future. This information is available at <http://www.freepatentsonline.com/5295759.html>

Improvement Option 5c - Narrow the Gravel Roadway

Narrowing the roadway to 24 feet wide would tend to slow down roadway users. This could be an effective option for encouraging reduced travel speeds. This situation could occur on the NFFR particularly since the gravel has been reported to reach widths much wider than the originally constructed gravel roadway and users may drive faster on wider roads.

Improvement Option 5d - Police Car with Dummy

A durable inexpensive (approximately \$2,000) mannequin can be placed in an older or out of service police patrol car. This has been shown as an effective means to slow drivers down as they approach what appears to be an active law enforcement vehicle. A recent article regarding this type of speed deterrent on US93 in Montana is available for review in this appendix (page 62).

This technique is also used in rural Utah with success, particularly in Kane County, as well as on a 25 mph speed limit roadway in Delaware, and is discussed on this website: <http://www.freepatentsonline.com/5295759.html>

This improvement option suggests the use of a lifelike dummy placed in a police car, which would then be parked along the corridor and moved bi-weekly. The proposed use of this methodology as an improvement option would not preclude existing law enforcement practices in the study corridor.

Improvement Option 5e - Additional Signage (Safety or Speed Limit)

Currently there is one speed limit sign at the transition from the pavement to gravel section of the roadway, at the south end of the study area (approximately RP 12.4), and one at the north end near Camas Road (approximately 22.5).

In an effort to remind drivers to slow down, this improvement option would include additional speed limit signage, and warning signs strategically placed to reduce accidents due to unsafe conditions. Specific locations of additional signage would need to be studied and identified for appropriate placement.

Improvement Option 5f - Fund Additional Law Enforcement

There is currently one enforcement officer or “dust cop” who is responsible for hundreds of miles of dirt roadways in Flathead County. This officer can issue tickets to drivers of vehicles that are speeding and creating excessive dust. An average cost for another law enforcement officer is

approximately \$97,000 per year, which includes any benefits and overhead costs for an additional employee.¹

Improvement Option 5g- Education to Reduce Speeds

This option could be similar to other educational efforts used by state and local governments to reduce drunk driving or driving without seat belts. Education would not likely reach many of the non-local roadway users, thus the cost/benefit ratio is difficult to assess. Discussion of the combination of education efforts, engineering and enforcement is available in a traffic calming newsletter at: http://www.trafficlogix.com/newsletters_details.asp?id=69

Bituminous Surface Treatment/Asphalt Concrete Pavement

A variety of full roadway surface rehabilitation options were discussed during the improvement options analysis and considerations. The various options were narrowed down to the four options described below. All options under item 6 would pave the existing alignment, which was redesigned in 1987 to meet a 40 to 50 mph design criteria, and not consider realignment.

The MDT Geotechnical memorandum recommended a preliminary pavement section of three inches of asphalt surfacing and three inches crushed aggregate on top of the existing gravel base. The construction to full pavement (36 foot, 24 foot, or Foamed Asphalt) options would result in maintenance of HWY 486 shifting from Flathead County to MDT.

An additional suggestion given by study team members and members of the public would be to include wildlife crossing structures with each of the following paving options, to help mitigate vehicle-wildlife crashes. These structures would include off-roadway fencing to direct wildlife towards the crossing. The cost of such structures was not included for these options, due to the lack of data on accidents and difficulty quantifying where and how many structures might be needed. A single structure would likely cost approximately \$500,000. Placing structures even as far apart as a mile could add up to \$13 million to any projected costs, which could be cost-prohibitive.

Improvement Option 6a – Full Pavement – complete 36 foot width

This would be a typical commercial-mix pavement of asphalt, with 12 foot lanes, six foot shoulders, and a chip seal on top. The lifespan of the pavement is anticipated to be 20 years, and maintenance would follow a pavement preservation plan which would typically include crack sealing every two years and chip sealing five to seven years. MDT typically chip seals a pavement the same year or the year after placement, which drastically reduces raveling and degradation of the road.

Photos and information related to raveling are located at:
<http://pavementinteractive.org/index.php?title=Raveling>

Many publications are available to further research chip seal methods at:
http://www.fhwa.dot.gov/pavement/pub_details.cfm?id=39

Improvement Option 6b – Full Pavement – 24 foot top, 11 foot travel ways

This improvement option would be very similar to Improvement Option 6a, but with narrower 11 foot lanes and one foot paved shoulders before the gravel side slopes. This option would

¹ Personal Communication between Flathead County and P.B. Americas, Inc., June 2010.

decrease the amount of pavement material used in the paving process and the total roadway area that would need to be maintained, while still reducing dust, if non-paving options were utilized. The narrower road may also contribute to reduced travel speeds in the same way that the narrower the gravel road could contribute (Option 5c).

Improvement Option 6c – Millings/asphalt (with chip seal)

This pavement source would be asphalt milled from other roadways versus a completely new surface overlay of asphalt pavement. As the millings were available they would be placed on the road to a 26 foot width, compacted and topped with a chip seal,

The advantages are that millings can be obtained from any roadway project, because they are state property, which could potentially reduce total future project costs. The costs could be lower than other new pavement options shown in Improvement Options 6a and 6b. This would be as a result of other projects hauling the milling materials to a nearby MDT stockpile. The hauling costs to the NFFR area would not be covered by the project removing the materials, but by any future NFFR study area roadway/potential project funds.

Some disadvantages are that availability of the milling materials in the future is an unknown factor; the NFFR would thus likely have to be improved incrementally, i.e. section by section, not all at once, which may affect funding, as costs are likely to increase into the future. As milling materials could be placed on the current gravel sections of the study area roadway a chip seal treatment would also be required.

Improvement Option 6d - Foamed Asphalt Mix (with Double Shot):

Foamed Asphalt Mix would result in a surface similar to a typical asphalt pavement. The gravel roadway would need to be graded and sloped for treatment. Additional gravel surfacing would be required to allow for adequate surface depth. Once roadway grading and graveling is completed, the foamed asphalt mix treat could be applied. This would be completed by mixing the gravel surface with the foamed mix, relaying the surfacing, and compaction of the mix to the desired thickness. Since the treatment is similar to typical asphalt pavement the life cycle costs are also similar. The roadway maintenance would include chip sealing every 7 to 10 years and other standard treatments such as crack sealing or patching.

This is an asphalt pavement which is considered a “warm mix.” This means that the plant making the mix runs cooler, thus saving money, and the pavement does not release volatiles into the air when being placed, like typical “hot mix” does. This option is for a 26 foot wide road, with a double-shot on top. Another advantage is that foamed asphalt is easier to compact, so contractors save money on compaction. To-date, warm mix has met all of the MDT specifications. Foamed asphalt warm mix has been used extensively in the Midwest on secondary roads.

A report recommended by MDT staff, Foamed Asphalt Mixes – Mix Design Procedure, Report # CR-98/077, authored by K. M. Muthen, has extensive information about this method.

Additional information concerning this improvement option can be found in this appendix, beginning on page 11.

External

Contract Report CR-98/077

Foamed Asphalt Mixes

Mix Design Procedure

K M Muthen

Programme : Road Engineering
Programme Manager : B M J A Verhaeghe
Technical Review : B M J A Verhaeghe

DOCUMENT RETRIEVAL PAGE			Report No: CR-98/077				
Title: Foamed Asphalt Mixes - Mix Design Procedure							
Author: K M Muthen							
Client: SABITA	Client Report No:	Date: Dec 1998	Distribution: External				
Project No: TRA79	OE2: 9472		ISBN:				
<p>Abstract:</p> <p>Foamed asphalt epitomizes the asphalt industry's drive towards energy efficient, environmentally friendly and cost-effective solutions for road-building. Foamed asphalt refers to a bituminous mixture of road-building aggregates and foamed bitumen, produced by a cold mix process. Although the foamed bitumen process was developed more than 40 years ago and lauded by researchers the world over, it is believed that the lack of standardized design procedures has contributed to the limited implementation of the technology in South Africa, with practitioners favouring more familiar and well documented products. Recently there has been significant interest in the product, especially in the in-situ method of construction, and hence the need for a standard mix design procedure has now become essential. One element of foamed asphalt technology which may prove to be an impediment to standardization is the emergence of various proprietary bitumen foaming techniques.</p> <p>This report focusses on the development of a mix design method for foamed asphalt mixes, based on research work conducted at CSIR Transportek on behalf of SABITA. An extensive survey was undertaken of the worldwide practice with regard to foamed asphalt mix design, which included literature surveys and liaison with recognized experts. A mix design procedure was developed, encompassing all the necessary elements from the selection of aggregates and binder to the determination of the optimum engineering properties of the mix. This was followed by a laboratory program designed to verify the proposed mix design procedure. It is believed that the proposed mix design procedure is independent of the type of bitumen foaming process used and should, therefore, be acceptable to practitioners.</p>							
<p>Keywords:</p> <p>foamed bitumen, foamed asphalt, expanded asphalt, expanded bitumen, FOAMMIX, FOAMSTAB</p>							
<p>Proposals for further research:</p>							
<p>Related documents:</p>							
<p>Signatures:</p> <table border="1"> <tr> <td>C M Mac Carron Language editor</td> <td>B M J A Verhaeghe Technical Reviewer</td> <td>B M J A Verhaeghe Programme Manager</td> <td>A van der Merwe Info Centre</td> </tr> </table>				C M Mac Carron Language editor	B M J A Verhaeghe Technical Reviewer	B M J A Verhaeghe Programme Manager	A van der Merwe Info Centre
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ACKNOWLEDGEMENTS

The technical information, guidance and assistance provided by the following people and organizations is appreciated.

Alan Crawford, CSIR Transportek

Tony Lewis, AA Loudon & Partners Consulting Engineers

Hennie Loots, Bitutek Laboratories (Pty) Ltd.

Ciaran Mac Carron, CSIR Transportek

Sam Maccarrone, Mobil Australia

Hechter Theyse, CSIR Transportek

Chris Semmelink, CSIR Transportek

Benoit Verhaeghe, CSIR Transportek

Rob Vos, SABITA Ltd

1 INTRODUCTION

1.1 General

An essential ingredient in the success of the South African pavement industry is the sustained research, development and implementation of new and alternative road-building methods, motivated by reasons of economy and the scarcity of pavement materials. It is generally accepted that soil stabilization techniques are suitable for upgrading poor quality materials so that these materials may be used to their full potential in the pavement structure. Bitumen soil stabilization technology has been the focus of recent research initiatives which have resulted in refined mix design procedures for products such as GEMS and ETBs, i.e. bitumen emulsion-treated materials. A common aspect of bitumen soil stabilization is the incorporation of small amounts of binder, in a cold mixing procedure, which vastly increases the shear (cohesion) strength, fatigue resistance and moisture resistance of the treated materials. Although cold mix bituminous products were used in South Africa prior to the research initiatives, their use and benefits are now gaining increased acceptance within the industry.

The use of foamed asphalt, an alternative cold mix procedure, has also had limited application in the construction of road pavements in South Africa. However, no standardized mix design procedure is available. Although the foamed bitumen process was developed more than 40 years ago and lauded by researchers the world over, it is believed that the lack of standardized design procedures has contributed to the limited implementation of this technology in South Africa, practitioners favouring more familiar and well documented products.

1.2 Aim and Scope

The objective of this project is to develop and verify a mix design procedure for foamed asphalt. This document contains a literature review of published research findings on foamed asphalt. Information from previous research and current practice was used to develop guidelines for foamed asphalt mix design for use in South Africa.

1.3 Definition of Foamed Asphalt

The term 'foamed asphalt', as used in this document, refers to a mixture of pavement construction aggregates and foamed bitumen. The foamed bitumen, or expanded bitumen, is produced by a process in which water is injected into the hot bitumen, resulting in spontaneous foaming. The physical properties of the bitumen are temporarily altered when the injected water, on contact with the hot bitumen, is turned into vapour which is trapped in thousands of tiny bitumen bubbles. However the foam dissipates in less than a minute and the bitumen resumes its original properties. In order to produce foamed asphalt, the bitumen has to be incorporated into the aggregates while still in its foamed state.

2 OVERVIEW AND ADVANTAGES OF FOAMED ASPHALT

2.1 General

The potential of foamed bitumen for use as a soil binder was first realised in 1956 by Dr. Ladis H. Csanyi, at the Engineering Experiment Station in Iowa State University. Since then, foamed asphalt technology has been used successfully in many countries, with corresponding evolution of the original bitumen foaming process as experience was gained in its use. The original process consisted of injecting steam into hot bitumen. The steam foaming system was very convenient for asphalt plants where steam was readily available but it proved to be impractical for in situ foaming operations, because of the need for special equipment such as steam boilers. In 1968, Mobil Oil Australia, which had acquired the patent rights for Csanyi's invention, modified the original process by adding cold water rather than steam into the hot bitumen. The bitumen foaming process thus became much more practical and economical for general use.

Foaming increases the surface area of the bitumen and considerably reduces its viscosity, making it well suited for mixing with cold and moist aggregates. Foamed bitumen can be used with a variety of materials, ranging from conventional high-quality graded materials and recycled pavement materials to marginal materials such as those having a high plasticity index. Foamed asphalt can be manufactured in situ or in a central plant. Binder contents are based on the mix design, and are determined as percentage (by weight) required for the mix to have optimum properties.

2.2 Advantages of Foamed Asphalt Mixes

The following advantages of foamed asphalt are well documented:

- The foamed binder increases the shear strength and reduces the moisture susceptibility of granular materials. The strength characteristics of foamed asphalt approach those of cemented materials, but foamed asphalt is flexible and fatigue resistant.
- Foam treatment can be used with a wider range of aggregate types than other cold mix processes.
- Reduced binder and transportation costs, as foamed asphalt requires less binder and water than other types of cold mixing.
- Saving in time, because foamed asphalt can be compacted immediately and can carry traffic almost immediately after compaction is completed.
- Energy conservation, because only the bitumen needs to be heated while the aggregates are mixed in while cold and damp (no need for drying).
- Environmental side-effects resulting from the evaporation of volatiles from the mix are avoided since curing does not result in the release of volatiles.

- Foamed asphalt can be stockpiled with no risk of binder runoff or leeching. Since foamed asphalt remains workable for very extended periods, the usual time constraints for achieving compaction, shaping and finishing of the layer are avoided.
- Foamed asphalt layers can be constructed in adverse weather conditions, such as in cold weather or light rain, without affecting the workability or the quality of the finished layer.

3 DESIGN CONSIDERATIONS

3.1 General

In this section the key design parameters that need to be considered in a mix design for foamed asphalt materials are discussed. The objective of a foamed asphalt mix design is to select the mix proportions, one of which is bitumen content, in order to achieve:

- optimum values for laboratory-measured properties;
- the structural and functional requirements of the in-service mix, and
- retention of the relevant engineering properties at in-service conditions of temperature, moisture and loading conditions.

Laboratory tests conducted on foamed asphalt should evaluate resistance to deformation, as well as variations in cohesion and strength with moisture and temperature. As the strength of foamed asphalt mixes is extremely sensitive to moisture conditions, these should be taken into account in the test methods. Because foamed asphalt mixes can take on characteristics ranging from granular materials to those of high quality asphalt materials, the test method selected should be able to handle a wide range of material types. It is advisable to correlate field performance with laboratory test results in order to develop suitable target values (criteria) for the laboratory-measured properties.

3.2 Bitumen Properties

Foamed bitumen, also referred to as expanded bitumen, is a hot bituminous binder which has been temporarily converted from a liquid to a foam state by the addition of a small percentage of water (typically 2 per cent). The foamed bitumen is characterized in terms of expansion ratio and half-life. The **expansion ratio** of the foam is defined as the ratio between the maximum volume achieved in the foam state and the final volume of the binder once the foam has dissipated. The **half-life** is the time, in seconds, between the moment the foam achieves maximum volume and the time it dissipates to half of the maximum volume

3.2.1 Foaming Potential

The foaming characteristics of bitumen play an important role during the mixing stage of foamed asphalt production. It can be expected that maximized expansion ratios and half-lives will promote binder dispersion within the mix. Castedo Franco and Wood (1983) found that any bitumen, irrespective of grade or origin, could be foamed with an appropriate combination of nozzle type, water, air and bitumen injection pressure. However, Abel (1978) found that:

- bitumen which contained silicones could have reduced foaming abilities;
- bitumens with lower viscosities foamed more readily and had higher foam ratios and half-lives than bitumens with higher viscosities, but the use of high viscosity bitumens resulted in superior aggregate coating;
- anti-stripping agents intensified the foaming ability of bitumens, and
- acceptable foaming was only achieved at temperatures above 149° C.

Brennen et al (1980) found that the half-life and expansion ratio of the foam produced from any particular bitumen was affected by the volume of foam produced, the quantity of water used and the temperature at which the foam was produced. Higher foaming temperatures and increased quantities of water both resulted in increased expansion ratios, but resulted in decreased half-lives. In the laboratory, the size of the container was found to affect the foam parameters (Ruckel et al,1983). Ruckel et al (1983) recommend limits of 8-15 for the expansion ratio and at least 20 seconds for the half-life. By using certain surface-active additives it is possible to produce highly expanded and stable foamed bitumens with expansion ratios greater than 15 and half-lives greater than 60 seconds (Maccarrone et al, 1995).

Bowering and Martin (1976) showed that the cohesion and compressive strength of mixes were significantly greater when high expansion (15:1) foamed bitumen was used. Maccarrone et al (1995) suggested that high expansion foamed bitumen resulted in improved aggregate coating and, hence, in improved mix properties.

3.2.2 Grade of bitumen grade

The results of previous research do not show any appreciable differences between the measured properties of foamed asphalt mixes produced with different grades of bitumen (Lee, 1981). This is probably related to the fact that much of the shear strength of foamed asphalt mixes is due to aggregate interaction rather than binder cohesion (see section 3.3). However, the load rate and temperature-dependent behaviour of foamed asphalt mixes (see sections 3.7.2 and 3.7.5) are indicative of the viscoelastic binder activity. This aspect needs to be investigated further.

3.2.3 Foamed Bitumen Content (BC)

In foamed-asphalt mixes the optimum bitumen content often cannot be clearly determined as it can in the case of hot-mix asphalt. The range of binder contents (BC) that can be used is limited by the loss in stability of the mix at the upper end of the range and by water susceptibility at the lower end. It appears that one significant parameter is the ratio of binder content to fines content, i.e. the viscosity of the binder-fines mortar plays a significant role in mix stability (see section 3.3). Table 3.1 may be used as a guide to select the appropriate binder content based on the fines content of the mix. Akeroyd and Hicks (1988) also proposed the use of a proportional binder-fines relationship to select the binder content, ranging from a binder content of 3,5 per cent binder for 5 per cent fines content to a binder content of 5 per cent for 20 per cent fines content. However this approach may not be applicable for all types of material, because of the varying binder absorption characteristics of fines which, in turn, depend on the source (parent) material.

TABLE 3.1 : Foamed bitumen content (after Ruckel et al, 1982)

% passing 4,75 mm sieve	% passing 0,075 mm sieve	% Foamed bitumen
< 50 (gravels)	3 - 5	3
	5 - 7,5	3,5
	7,5 - 10	4
	> 10	4,5
> 50 (sands)	3 - 5	3,5
	5 - 7,5	4
	7,5 - 10	4,5
	> 10	5

3.3 Aggregate Properties

Research has shown that a wide range of aggregates may be used with foamed-bitumen, ranging from crushed stone to silty sands and even to ore tailings, as shown in Table 3.2. Certain types of soil may require lime treatment and grading adjustments to enable them to perform satisfactorily. Figure 3.1 shows the Mobil foam stabilization grading chart (Akeroyd and Hicks, 1988). Materials conforming to Zone A of the chart have been found to be suitable for foam treatment for heavily trafficked roads. Materials conforming to Zone B are suitable for lightly trafficked roads, but could be adjusted to Zone A materials by the addition of coarse fractions. Materials in Zone C are deficient in fines and are not appropriate for foam stabilization unless fines are added.

The fines content of the aggregate is an important consideration and should preferably be above 5 per cent (Ruckel et al, 1982). The ability of foamed bitumen to selectively mix with and coat the fines (minus 0,075 mm particles) has been well documented. The resultant filler (mix of bitumen and fines), which has a significantly higher viscosity than the raw bitumen, acts as a mortar between the coarse aggregates and hence increases the strength of the mix. However, the relationship between the fines content and bitumen content is critical because excess bitumen in the mortar will tend to act as a lubricant and result in loss of strength and stability. Sakr and Manke (1985) showed that foamed asphalt mixes with higher percentages of fines had higher stabilities, while Bissada (1987) showed a similar trend for tensile strength. Semmelink (1991) also showed that the fines content played a crucial role in determining the strength, stability and workability of foam-stabilized sands.

In a limited study, Sakr and Manke (1985) showed that the stability of foamed asphalt mixes is affected to a greater extent by the aggregate interlock than by the viscosity of the binder, its behaviour thus differing from that of hot-mix asphalt. This implies that foamed asphalt mixes are not as temperature susceptible as hot-mix asphalt, and support the finding that the viscosity (grade) of the bitumen used is not very critical for foamed asphalt mixes (see section 3.2.2). Sakr and Manke (1985) also found that the angularity of fine aggregates is an excellent indicator of suitability for foam stabilization. A minimum particle index of 10 was suggested in order to achieve good stabilities.

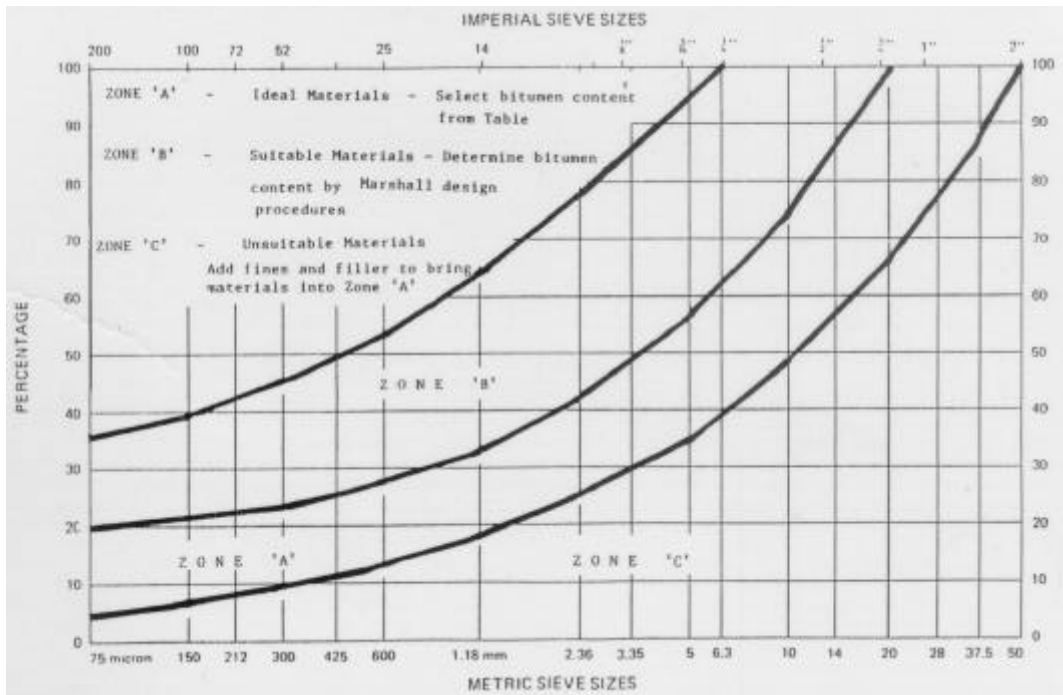


Figure 3.1 : Aggregate grading zones for foamed asphalt (Akeroyd & Hicks, 1988)

Table 3.2 : Foam treated materials (adapted from Bowering & Martin, 1976)

Soil type	Opt. range of binder contents (%)	Additional requirements
well graded clean gravel	2 - 2,5	
well graded marginally clayey / silty gravel	2 - 4,5	
poorly graded marginally clayey gravel	2,5 - 3	
clayey gravel	4 - 6	lime modification
well graded clean sand	4 - 5	filler
well graded marginally silty sand	2,5 - 4	
poorly graded marginally silty sand	3 - 4,5	low pen bitumen; filler
poorly graded clean sand	2,5 - 5	filler
silty sand	2,5 - 4,5	
silty clayey sand	4	possibly lime
clayey sand	3 - 4	lime modification

3.4 Moisture Conditions

The moisture content during mixing and compaction is considered by many researchers to be the most important mix design criteria for foamed asphalt mixes. Moisture is required to soften and breakdown agglomerations in the aggregates, to aid in bitumen dispersion during mixing and for field compaction. Ruckel et al (1982) recommend that the moisture-density relationship be considered in the formulation of trial mixes. Insufficient water reduces the workability of the mix and results in inadequate dispersion of the binder, while too much water lengthens the curing time, reduces the strength and density of the compacted mix and may reduce the coating of the aggregates. The optimum moisture content (OMC) varies, depending on the mix property that is being optimized (strength, density, water absorption, swelling). However, since moisture is critical for mixing and compaction, these operations should be considered when optimizing the moisture content.

Investigations by Mobil Oil suggest that the optimum moisture content for mixing lies at the “fluff point” of the aggregate, i.e. the moisture content at which the aggregates have a maximum loose bulk volume (70 % - 80 % mod AASHTO OMC) . However, the fluff point may be too low to ensure adequate mixing (foam dispersion) and compaction, especially for finer materials. Bowering (1970) observed that where inadequate foam dispersion occurred as a result of insufficient mixing moisture, the compacted densities were low and no benefit was gained from the foamed bitumen treatment. Lee (1981) found that the optimum mixing moisture content occurs in the range of 65 - 85 per cent of the modified AASHTO OMC for the aggregates. This optimum range of moisture contents for mixing was confirmed by Bissada (1987).

The concept of optimum fluid content as used in granular emulsion mixes may also be relevant to foamed asphalt. This concept considers the lubricating action of the binder in addition to that of the moisture. Thus the actual moisture content of the mix for optimum compaction is reduced in proportion to the amount of binder incorporated. Castedo Franco and Wood (1983) also agree that the best compactive moisture condition occurs when the total fluid content (moisture + bitumen) is approximately equal to the OMC.

Sakr and Manke (1985) developed a relationship (Equation 3.1) to calculate the moisture content for maximum density of foamed asphalt mixes, which considers the modified AASHTO OMC, and percentage of fines (PF) of the aggregate and the bitumen content (BC). As suggested by the equation, the higher the bitumen content the lower the compaction moisture content.

$$MMC=8,92+1,48OMC+0,4PF-0,39BC \qquad \text{Equation 3.1}$$

The optimum moisture content for mixing is approximately 10 to 20 per cent higher than the compaction moisture (MMC), as predicted by Equation 3.1. In order to prevent the time-consuming task of drying the mix after mixing (to achieve the MMC), Sakr and Manke (1985) suggested that the MMC be used for both mixing and compaction, as no significant differences in mix properties were observed when this procedure was used.

In recent years the gyratory compaction method has gained popularity for the preparation of samples in the laboratory. Because the gyratory compaction effort is usually higher than the

Modified AASHTO effort, the OMC obtained is lower than Modified AASHTO OMC. Hence, when gyratory compaction is used for the preparation of foamed asphalt, the OMC is advocated for mixing and compaction (Maccarrone et al, 1995) (as opposed to the moisture content on the dry side of OMC as used in Mod AASHTO compaction).

3.5 Curing Conditions

Studies have shown that foamed asphalt mixes do not develop their full strength after compaction until a large percentage of the mixing moisture is lost. This process is termed curing. Curing is the process whereby the foamed asphalt gradually gains strength over time accompanied by a reduction in the moisture content. Ruckel et al (1982) concluded that the moisture content during the curing period had a major effect on the ultimate strength of the mix. However, Lee (1980) provided experimental evidence which suggested that moisture loss was not a prerequisite for strength gain in foamed asphalt mixes. Whichever the case, a laboratory mix design procedure would need to simulate the field curing process in order to correlate the properties of laboratory- prepared mixes with those of field mixes. Since the curing of foamed asphalt mixes in the field occurs over several months, it is impractical to reproduce actual field curing conditions in the laboratory. An accelerated laboratory curing procedure is required, in which the strength gain characteristics can be correlated with field behaviour, especially with the early, intermediate and ultimate strengths attained. This characterization is especially important when structural capacity analysis, based on laboratory-measured strength values, is required.

Most of the previous investigations have adopted the laboratory curing procedure proposed by Bowering (1970), i.e. 3 days oven curing at a temperature of 60° C. This procedure results in the moisture content stabilizing at about 0 to 4 per cent, which represents the driest state achievable in the field. The strength characteristics of samples cured in this manner are representative of the in-service state approximately a year after construction (Maccarrone, 1995). Concerns have been expressed over the binder ageing which may occur at a curing temperature of 60° C. Also, since this temperature is above that of the softening point of common road-grade bitumens, changes in bitumen dispersion within the mix are possible during curing. These issues will be addressed during the laboratory validation phase of this study. An alternative approach suggested by Lewis (1998) would be to oven dry the foamed asphalt to a constant mass, at a lower temperature (40° C).

3.6 Temperature Conditions

The optimum mixing temperature of the aggregates for foamed asphalt mixes lies in the range of 13° C to 23° C, depending on the type of aggregate, Temperatures below this range result in poor quality mixes (Bowering and Martin, 1986). Foamed asphalt mixes may also be prepared with heated aggregates which will increase the binder dispersion within the mix and aid in the coating of the larger aggregates.

3.7 Engineering Properties

The results of previous studies all confirm that strength parameters such as Resilient Modulus, CBR and stability are optimized at a particular intermediate binder content. The most common method used in the selection of the design binder content was to optimize the Marshall stability and minimize the loss in stability under soaked moisture conditions. The major functions of foamed bitumen treatment are to reduce the moisture susceptibility, to increase fatigue resistance and to increase the cohesion of the untreated aggregate to acceptable levels. The design foamed bitumen content could also be selected as the minimum (not necessarily optimum) amount of binder which would result in a suitable mix.

3.7.1 Moisture Susceptibility

The strength characteristics of foamed asphalt mixes are highly moisture-dependent. This is because of the relatively low binder contents and high void contents of foamed asphalt mixes. Castedo Franco et al (1984) found that additives such as lime reduced the moisture susceptibility of the mixes. Cement was also found to be as effective as lime, and cheaper (Lewis, 1998). Higher bitumen contents also reduce moisture susceptibility because higher densities are achievable, leading to lower permeabilities (lower void contents), and to increased coating of the moisture-sensitive fines with binder.

3.7.2 Temperature Susceptibility

Foamed asphalt mixes are not as temperature-susceptible as hot-mix asphalt, although both the tensile strength and modulus of the former decrease with increasing temperature. Bissada (1987) found that, at temperatures above 30° C, foamed asphalt mixes had higher moduli than equivalent hot-mix asphalt mixes after 21 days' curing at ambient temperatures. In foamed asphalt, since the larger aggregates are not coated with binder, the friction between the aggregates is maintained at higher temperatures. However the stability and viscosity of the bitumen-fines mortar will decrease at high temperatures, thus accounting for the loss in strength.

3.7.3 Unconfined Compressive Strength (UCS) and Tensile Strength

Bowering (1970) suggested the following UCS criteria for foamed asphalt mixes used as a base-courses under thin surface treatments (seals): 0,5 MPa (4 day soaked) and 0,7 MPa (3 day cured at 60° C). Bowering and Martin (1976) suggested that in practice the UCS of foamed asphalt materials usually lie in the range 1,8 MPa to 5,4 MPa and estimated that the tensile strengths of foamed asphalt materials lay in the range 0,2 MPa to 0,55 MPa, depending on moisture condition. They also found that foamed asphalt had strength characteristics superior to those of emulsion-treated materials at bitumen contents above 1,5 per cent. Maccarrone (1998) recommended that, for good performance, cured foamed asphalt samples should have minimum Indirect Tensile Strengths of 100 kPa when tested in a soaked state and 200 kPa when tested dry. Curing has a significant influence on the strength of foamed asphalt mixes (Van Wijk and Wood, 1983).

3.7.4 Stiffness - Resilient Modulus

As with all viscoelastic bituminous materials, the stiffness of foamed asphalt depends on the loading rate, stress level and temperature. Generally, stiffness has been shown to increase as the fines content increases. In many cases the resilient moduli of foamed asphalt mixes have been shown to be superior to those of equivalent hot-mix asphalt mixes at high temperatures (above 30° C). Foamed asphalt can achieve stiffnesses comparable to those of cement-treated materials, with the added advantages of flexibility and fatigue resistance (Ramanujam and Fernando, 1997).

3.7.5 Abrasion Resistance

Foamed asphalt mixes usually lack resistance to abrasion and ravelling and are not suitable for wearing/friction course applications.

3.7.6 Density and Volumetrics

Generally density increases to a maximum and voids in the aggregate decreases to a minimum as the binder content of a foamed asphalt mix increases. Many studies have shown that the strength of foamed asphalt mixes depends to a large extent on the density of the compacted mix. Hence it is foreseeable that density and mix volumetrics could be used as criteria to determine the optimum binder content of a foamed asphalt mix.

3.7.7 Fatigue Resistance

Fatigue resistance is an important factor in determining the structural capacity of foamed asphalt pavement layers. Foamed asphalt mixes have mechanical characteristics that fall between those of a granular structure and those of a cemented structure. Bissada (1987) considers that the fatigue characteristics of foamed asphalt will thus be inferior to those of hot-mix asphalt materials. Little et al (1983) provided evidence of this when he showed that certain foamed asphalt mixes exhibited fatigue responses inferior to those of conventional hot-mix asphalt or high quality granular emulsion mixes. These findings are contradictory to those resulting from the approach adopted by Maccarrone et al (1993) who suggest that the fatigue characteristics of foamed asphalt are similar to those of hot-mix asphalt.

4 MIX DESIGN

4.1 General

The most commonly used mix design method for foamed bitumen has been that based on Marshall stabilities and densities. Generally, it has been observed that the Marshall stabilities of foamed asphalt mixes tended to increase to a maximum as the binder contents increased. The Marshall design criterion used to determine the optimum binder content is when the ratio between the wet and dry stabilities is at a maximum, i.e. the bitumen content at which the mix retains most of its strength when soaked. However, in recent times asphalt design methods, including foamed bitumen mix design, have seen a shift away from the Marshall methods, the emphasis now being placed on dynamic test procedures such as the dynamic creep test and the indirect tensile test. Based on experience in Australia, Lancaster et al (1994) recommended that the binder content selected for foamed asphalt mixes be based on the highest resilient modulus value. However, following recommendations by Lewis (1998), it is proposed that the Indirect Tensile Strength test be used to select a design binder content.

Based on the review of previous published investigations, the following mix design procedure is proposed. Procedures recommended in this mix design still need to be validated by laboratory investigation and are subject to change. Only the basic steps are outlined in this section, precise laboratory procedures being discussed in Appendix A.

4.2 Binder Characterization and Preparation

The foaming characteristics of a particular bitumen type need to be optimized for producing foamed asphalt mixes. This is achieved by measuring the half-life and the expansion ratio of foamed bitumen produced using various percentages of water. Usually five tests are conducted with the foaming water content varying from 1 per cent to 3 per cent at 0,5 per cent increments. The temperature of the bitumen before foaming should be in the range 180° C - 200° C. It is recommended that the half-life of the foamed bitumen be at least 12 seconds and the expansion ratio be at least 10:1. Additives may be used to catalyse the foaming. However, the use of these has a significant cost implication.

4.3 Aggregate Characterization and Preparation

The grading and the PI of the aggregates should be determined. The grading is adjusted, if required, by adding fines or coarse material so that the final grading conforms to the grading envelope in Figure 4.1. For low volume roads, aggregate gradings which lie above the target grading (finer), on sieves larger than 0,06 mm, may be acceptable. Materials which have a PI greater than 12 should be treated with lime to reduce the PI. In addition, it is common practice (Lewis, 1998) to add 1 - 2 per cent cement to the mix to aid in bitumen adhesion. The Modified AASHTO optimum moisture content of the aggregates is determined.

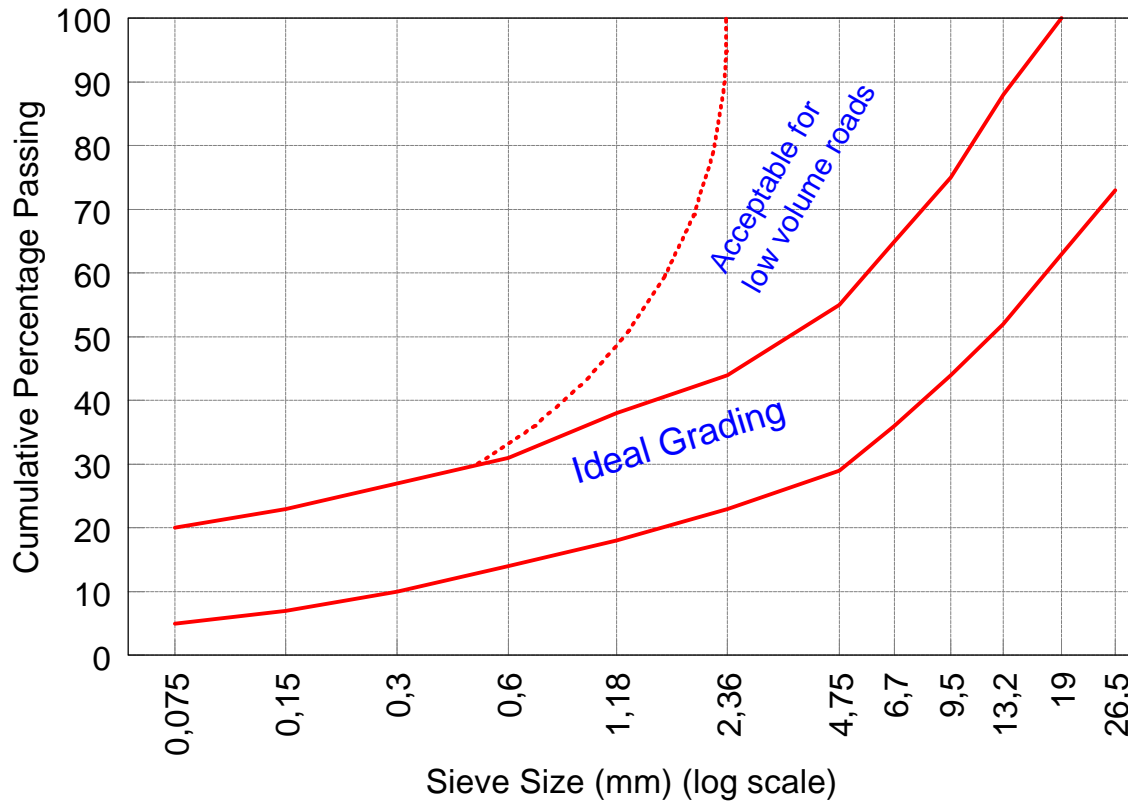


Figure 4.1 : Grading envelope for foamed asphalt mixes

The aggregates should be oven dried to a constant mass. The dried aggregates are riffled into 5 batches of 10 kg each. These will be used to produce 5 batches of foamed asphalt samples at various binder contents.

4.4 Binder Content (BC) for Trial Mixes

An appropriate range of foamed bitumen contents, using Tables 3.1 and 3.2 as a guide, is selected for the trial mixes. Five batches of trial mixes are normally prepared at binder contents differing by one per cent.

4.5 Moisture Content

The moisture content for mixing and compaction is a crucial mix design parameter, which has traditionally been selected at the 'fluff' point of the aggregates (70 - 80 per cent modified AASHTO OMC). However, it is recommended that the moisture content for mixing and compaction be selected at OMC minus the BC used for the Marshall method of compaction.

4.6 Mixing and Compaction

Each 10 kg sample of aggregate and the required mass of foamed bitumen (and lime or cement if required) are mixed in a mechanical mixer at the moisture content prescribed in section 4.5. The foamed asphalt is stored in sealed containers to prevent moisture loss, until all five batches have been mixed. Duplicate samples are removed from each foamed asphalt batch for the determination of moisture content and bitumen content. The remaining foamed asphalt will be used to prepare compacted foamed asphalt specimens for further testing.

For further foamed asphalt testing, it is suggested that eight samples be prepared from each batch: 6 samples for indirect tensile tests and 2 samples for volumetric evaluation. Specimens are compacted, using the Marshall hammer, to a 100 mm nominal diameter and 65 mm nominal height. Specimens of this size normally require about 1,15 kg of material. A compactive effort of 75 blows on each face is recommended.

4.7 Curing, Testing and Design Binder Content Determination

The foamed asphalt samples should be subjected to an accelerated curing procedure before undergoing any tests. The widely used procedure of 3 days' oven curing at 60° C is recommended. Indirect tensile strength testing is conducted to determine the ultimate strengths of both dry and soaked samples. Experts in the ARRB (Maccarrone, 1997) recommend that the dry and soaked indirect tensile strength should be at least 200 kPa and 100 kPa respectively. The **design binder content** should be selected as the binder content at which the soaked indirect tensile strength is at a maximum.

Resilient modulus testing at the design binder content is recommended. It has been noted in CSIR Transportek's laboratories that the loading time of 100 ms for the standard indirect tensile resilient modulus test may be too harsh for foamed asphalt samples. It is therefore recommended that a loading time of 50 ms (at 25° C) as proposed by Lancaster et al (1994) be adopted for foamed asphalt resilient modulus testing. Lancaster (1994) also proposed that the acceptance criteria for foamed asphalt mixes, with respect to resilient modulus, be at least 1500 MPa and 6000 MPa for soaked and dry samples respectively. However, the resilient modulus requirements depend on the structural requirements of the pavements.

Dynamic Creep testing at the design binder content is suggested in order to evaluate the permanent deformation characteristics of the foamed asphalt mixes. A minimum dynamic creep modulus of 20 MPa is proposed.

5 LABORATORY VERIFICATION

5.1 General

A laboratory testing program was conducted to verify the design procedure proposed in section 4. The main purpose was to ensure that the mix design could be achieved using the proposed test methods and to identify any shortcomings in the design procedure.

5.2 Laboratory program

In order to enable the results from this study to be used with confidence, it was decided to base the test mixes on actual in-service foamed asphalt pavements in KwaZulu-Natal. As Theyse (1997) had conducted a study on these pavements, test results were readily available for comparison purposes.

The required mixes were produced at Bitutek Laboratories in Durban, according to the procedures described in section 4. No major problems were reported with the mixing or compaction procedures. Compacted samples were tested using the dynamic loading facilities at CSIR Transportek. The trial mixes were subjected to Indirect tensile tests for determination of the design binder content. Additional samples were prepared at the design binder content, for further indirect tensile tests, dynamic creep tests and bending beam tests. The test results are tabulated in Appendix B.

Three aggregate gradings were considered, as shown in Table 5.1. The grading curves are shown in Figure 5.1. It can be seen that mix A does not conform to the grading envelope recommended in section 4.3. Mix A was treated with 2,5 per cent Fly-ash and 2,5 per cent lime to increase the fines content.

Table 5.1: Aggregate gradings

Mix	A	B	C
Source	Sodwana aeolian sand	Shongweni weathered granite	Shongweni weathered granite
Sieve Size (mm)	% Passing		
19,0		100	100
13,2		93	96
9,5		80	90
6,7		69	82
4,75		60	74
2,36		44	57
1,18	100	33	43
0,600	99	23	33
0,300	72	15	24
0,150	6	9	17
0,075	1	7	13

Table 5.2: Binder contents for trial mixes

Aggregate Type	Nom. Binder Contents (B12 or 60/70 pen.)
Mix A: Sodwana aeolian sand	3; 4; 5
Mix B: Shongweni weathered granite	3; 4; 5
Mix C: Shongweni weathered granite	4; 5; 6

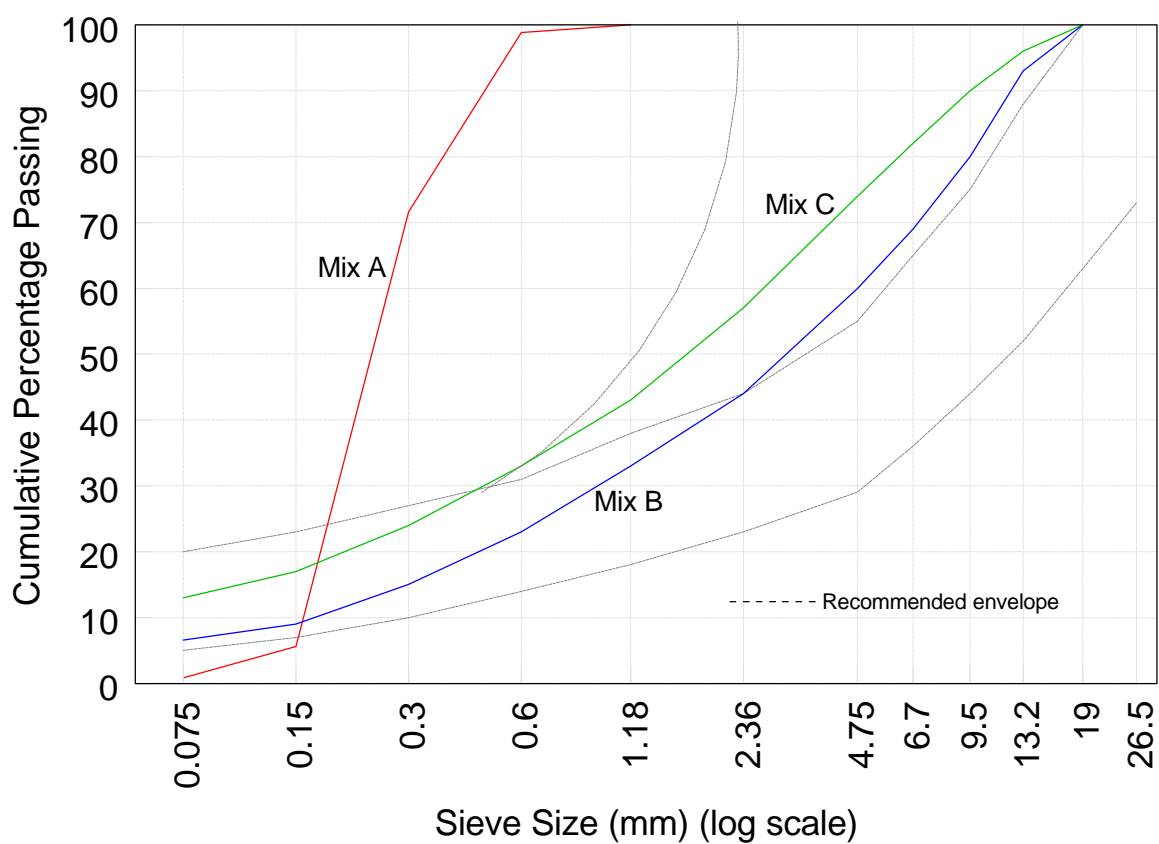


Figure 5.1 : Aggregate grading curves

5.3 Test Results for the trial mixes

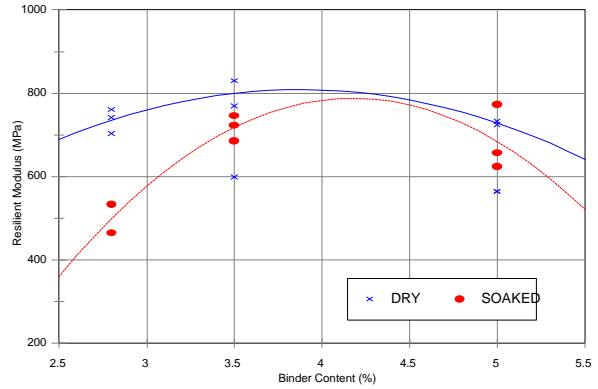
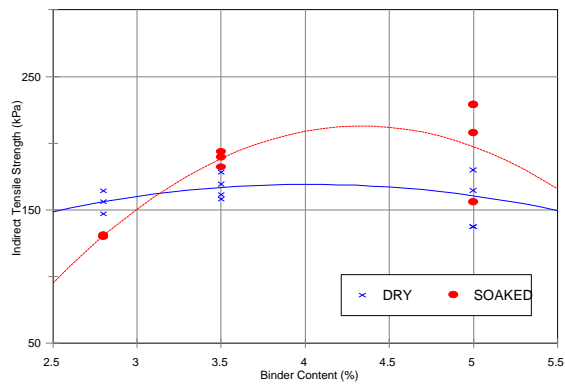


Figure 5.2: Indirect Tensile Test - Mix A

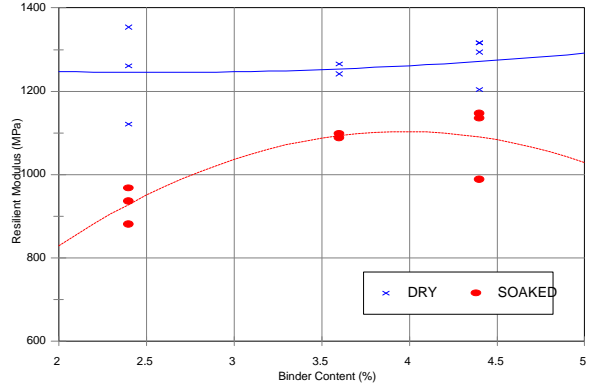
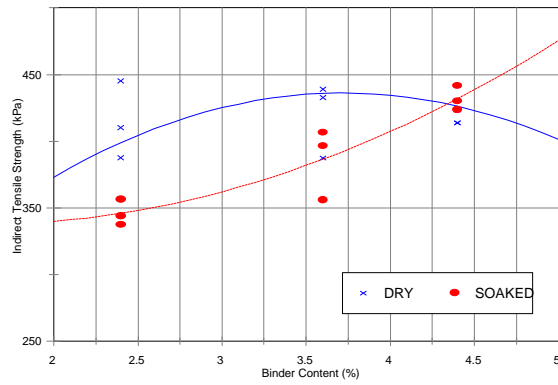


Figure 5.3 : Indirect Tensile Test - Mix B

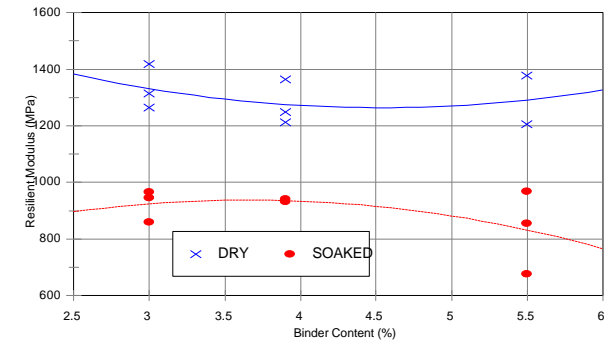
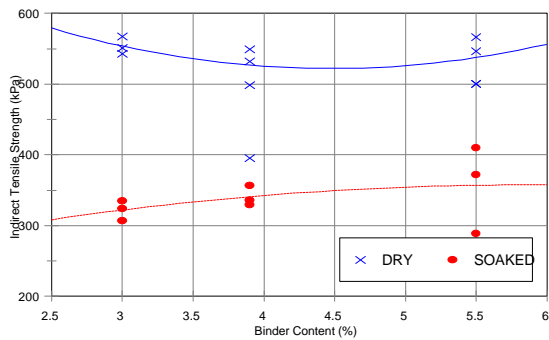


Figure 5.4 : Indirect Tensile Test - Mix C

5.4 Test results for the design mixes

Table 5.3: Tests on briquettes

Dry ITS	Wet ITS	Dry Res Mod	Wet Res Mod	Creep Mod.
Mix A: Sodwana aeolian sand (BC = 3.4%)				
113.30	132.20	571.70	456.50	early failure
Mix B: Shongweni weathered granite (BC = 3.6 %)				
529.23	197.65	1628.57	599.43	510.72
Mix C: Shongweni weathered granite (BC = 3.6 %)				
568.45	135.90	1477.80	282.20	235.79

Table 5.4: Test results from in-service pavement (extracted from Theyse,1997)

Test section	Test result			
	BC (%)	Voids (%)	ITS (dry) (kPa)	ITT (dry) (MPa)
Shongweni recycled asphalt km 3,00 - 3,20	5,9	10,7	422	1356
Shongweni weathered granite km 3,20 - 3,40	4,8	20,4	233	1261
Shongweni weathered granite km 3,40 - 3,60	4,3	10,5	287	1295
Sodwana aeolian sand	4 - 5	23,6	260	1239

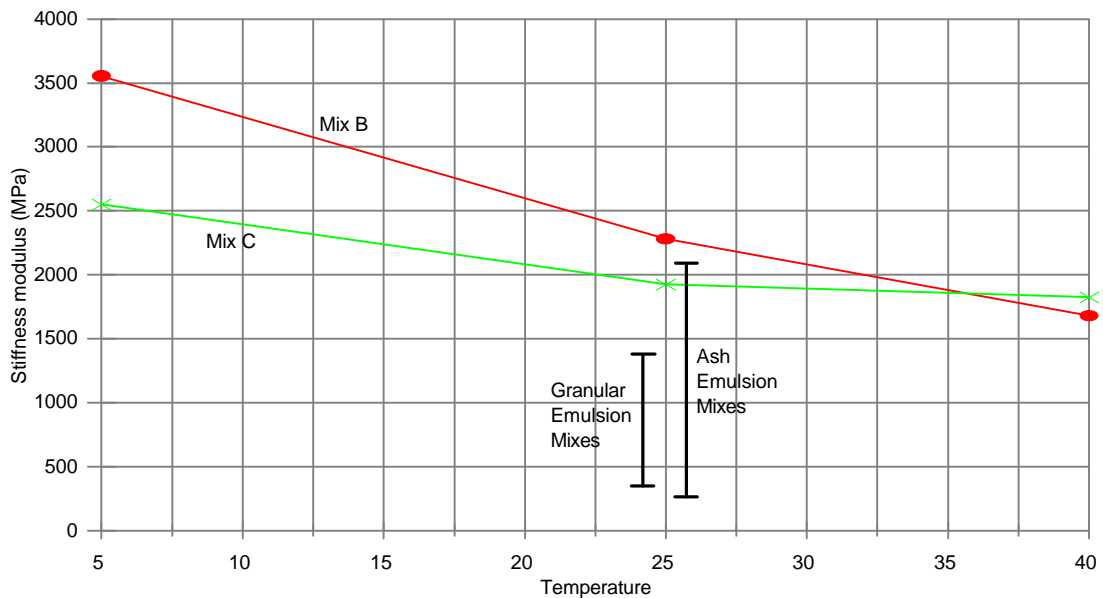


Figure 5.5 : Stiffness Moduli obtained from beam tests showing values obtained for bitumen treated granular and ash materials (at ambient temperature)

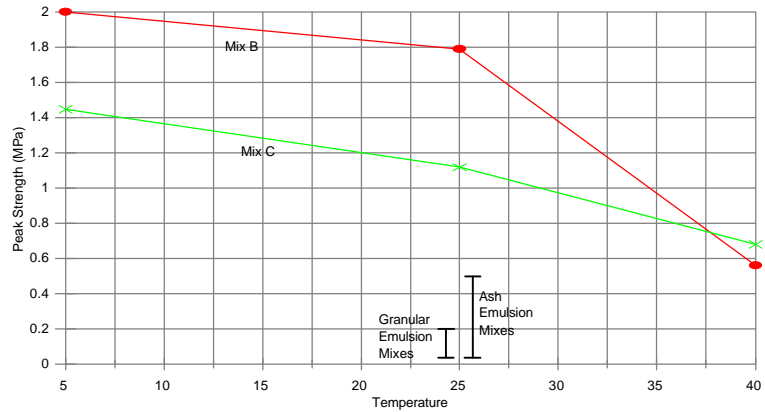
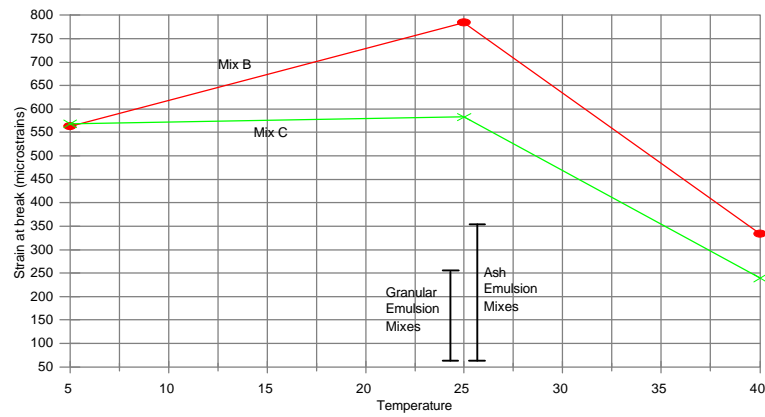


Figure 5.7: Peak stresses from the beam tests

5.5 Discussion of results

Generally the test results validate the expected decrease in strength when the materials are wet. The void contents for foamed asphalt mixes are very high (Table B1 in Appendix B) and thus highly permeable to water. The sand samples (mix A), however, show a small increase in strength when wet. It is possible that the hydration reaction of the lime+fly-ash modification contributed to this result.

It was not always possible to determine the optimum binder content solely from the soaked indirect tensile tests. In this case the other indirect tensile test results, and volumetric test results should be used to determine the design binder content. Apart from the sand mix, the foamed asphalt mixes performed relatively well, meeting the minimum criteria for both dry and wet ITS tests. This validates to some extent the grading restrictions proposed for fine, uniformly graded mixes. The sand mix was very brittle, and prone to damage on handling. However, the unconfined modes of testing may not be the best method of evaluating these mixes (uniformly graded), considering that sand mixes have been successfully used in field applications.

The beam tests were conducted at three temperatures, viz ambient (about 25°C), 5°C and 40°C. The results are shown in Figure 5.5 and Figure 5.6. As expected, the results indicate the temperature susceptibility of the material. The foamed asphalt mixes exhibited much higher stiffnesses than emulsion treated materials in the ambient temperature range and also tolerated strains 2 to 3 times larger than those tolerated by the emulsion treated materials, before failure.

It can be stated that the laboratory procedures result in mixes that are fairly representative of the field mixes, as can be seen if the results in Tables 5.3, 5.4 and B1 are compared.

6 CONCLUSION

Foamed asphalt cold mixes are gaining in popularity owing to their good performance, ease of construction and compatibility with a wide range of aggregate types. As with all bituminous mixes, it is essential to have a proper mix design procedure for foamed asphalt mixes in order to optimize the usage of available materials and to optimize mix properties. Fortunately, for foamed asphalt mixes, the mix design can be accomplished by relatively simple test procedures and by adhering to certain restrictions with respect to the materials used.

In this study, previous experience with foamed asphalt materials in other parts of the world was consolidated into a mix design guideline for use in South Africa. The mix design guideline follows a step-by-step procedure, from characterization of the raw materials through to the final testing of the compacted samples. Care was taken to ensure that the procedures adopted are compatible with standard test methods and currently accepted practice. Apart from a bitumen foaming plant, the mix design can be achieved with the standard equipment available in asphalt laboratories.

The central philosophy in the mix design is to optimize the mix strength characteristics at the worst-case operating environment, i.e. under soaked conditions. The indirect tensile strength test offers a convenient way of evaluating compacted foamed asphalt samples in this manner. Samples are compacted using standard Marshall compaction apparatus and then tested in a soaked condition. By conducting tests over a range of binder contents, the optimum binder content can be selected. Other tests, such as resilient modulus, dynamic creep and mix volumetrics, are also conducted in order to verify the selected optimum mix and to ensure adequate performance of the mix.

Many new techniques are being developed to achieve foaming of the bitumen. However, since the mix design proposed herein concentrates on optimizing the mix properties, it would work equally well with all foam asphalt mixes, irrespective of the type of apparatus used to produce the foamed bitumen.

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APPENDIX A : Laboratory Procedures for Mix Design

These procedures are mainly from the design guide provided by Tony Lewis (AA Loudon & Partners Consulting Engineers, 1998)

A.1 Apparatus

The following laboratory equipment is required to carry out the design of foamed asphalt mixes:

A laboratory foamed bitumen plant capable of producing foamed bitumen at a rate of between 50 g and 200 g per second. The method of production should closely simulate that of full-scale production of foamed bitumen. The apparatus should have a thermostatically controlled kettle capable of holding a mass of 10 kg of bitumen at between 150° C and 205° C, within a range of $\pm 5^\circ$ C. In addition, a low-pressure compressed air supply of 0 - 500 kPa with an accuracy of ± 25 KPa should be included in the apparatus. The plant should have a system of adding cold water to the hot bitumen, variable from 0 per cent to 4 per cent by mass, with an accuracy of 0,2 per cent. The plant should be designed so that the foam can be discharged directly into the mixing bowl of an electrically driven laboratory mixer with a capacity of at least 10 kg

Marshall compaction moulds, $101,6 \pm 0,5$ mm in diameter and $87,3 \pm 1$ mm high, with baseplate and extension collar to fit the moulds.

A Marshall compaction hammer with a $98,5 \pm 0,5$ mm diameter flat face and a 4536 ± 5 g sliding weight with a free fall of 457 ± 3 mm. The use of a mechanical hammer is optional.

A compaction pedestal consisting of a 203 x 203 x 457 mm wooden post capped with a 305 mm square steel plate. The pedestal shall be so installed that the post is plumb and the cap is level and must be provided with a rigid vertical guide for the hammer. The wooden post must be secured to a solid concrete slab.

A mould holder of suitable design to hold the mould in place during compaction.

A specimen extractor of suitable design to remove the briquette from the mould without damage.

A balance to weigh up to 5 kg accurate to 1 g.

A spatula with a blade of approximately 150 mm in length.

A compression testing machine capable of applying a load of at least 20 kN at a rate of 50,8 mm per minute, fitted with a load measuring device to measure a load of at least 15 kN and accurate to 0,1 kN.

An air cabinet capable of maintaining a temperature of 25° C $\pm 1^\circ$ C.

Two hardened steel loading strips, $13 \pm 0,1$ mm wide, each with a concave surface having a radius of curvature of 51 ± 1 mm and at least 70 mm long. The edges of the bearing surface should be rounded slightly to remove the sharp edge. The bearing strips should be mounted in a frame of suitable design to align the strips on the test specimen.

A steel load-transfer plate, round or square, to transfer the load from the compression testing machine to the top bearing strips without deformation. Its dimensions should be such that it will cover at least the length of the specimen to be tested on the bearing strip.

Callipers to measure the length and diameter of test specimens to the nearest 0,5 mm .

Silicone grease or oil (such as stop-cock grease)

A vacuum desiccator or other appropriate vessel and a vacuum pump capable of reducing pressure to less than 50 mm mercury, connected to a manometer.

A thermometer capable of measuring a temperature between 0° C and 50° C $\pm 0,2^\circ$ C.

A.2 Optimization of Foamed Bitumen Properties

The objective is to determine the percentage of water which will optimize the foaming properties of a particular bitumen by maximizing the expansion ratio and half-life of the foamed bitumen.

Calibrate the bitumen and water flow rates. Regulate the bitumen discharge rate to 100 grams per second. Regulate the air supply pressure to 100 kPa. Maintain the bitumen within the

temperature range of 180 - 200° C for at least 15 minutes before commencing with foam production. Five samples of foamed bitumen are required to be produced at moisture contents ranging from 1 per cent to 3 per cent in increments of 0,5 per cent.

For each sample, allow the foam to discharge for 5 seconds into a 20 litre steel drum. Mark the maximum volume to which the foam expands, using a marking pencil on the side of the drum. Using a stop watch, measure the time in seconds which the foam takes to dissipate to half of its maximum volume. This is defined as the half-life. Calculate the expansion ratio of the foamed bitumen by dividing the maximum foamed volume by the volume of bitumen in the drum after the foam has completely dissipated, after a period of at least 60 seconds. Plot the a graph of the expansion ratio and half-life versus moisture content for all the samples on the same set of axes, as shown in Figure A1. This will enable the moisture content to be optimized.

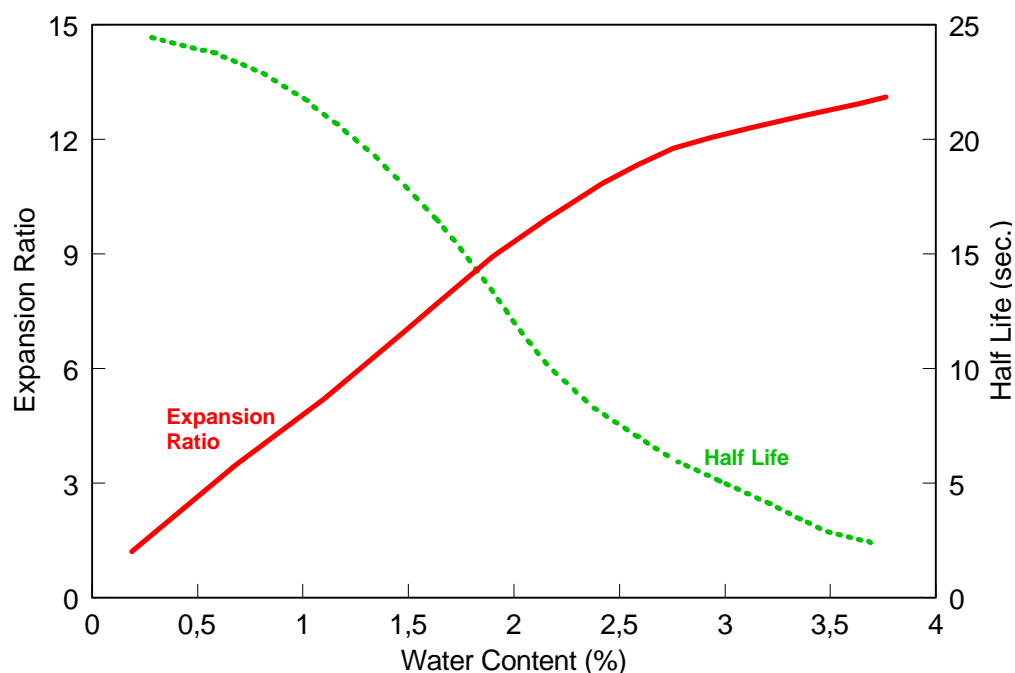


Figure A1: Optimizing foam properties.

A.3 Aggregate Preparation

Determine the gradation (refer to Method A1, TMH1) and plasticity index (refer to Method A3, TMH1) of the aggregates.

In some cases blending of more than one aggregate may be undertaken to provide the required grading (refer to section 4.2). At this stage cement, road lime or other fillers may be added if required. Lime treatment must be conducted if the PI of the aggregates is greater than 12.

Carry out a moisture/density relationship test, using the modified AASHTO method, so as to obtain the optimum moisture content (OMC) (refer to Method A7, TMH1).

The aggregate should be oven-dried to constant mass at 105° C. In the case of reclaimed bituminous materials, drying should be carried out at a lower temperature to prevent the particles from sticking together. The binder content of reclaimed bituminous materials should be determined at this stage. Once dry, the sample should be riffled and weighed into 10 kg batches.

A.4 Treatment of Aggregate Samples with Foamed Bitumen

For the mix design a total of five of the 10 kg batches, with bitumen contents 1 per cent apart, should be prepared. The laboratory foamed bitumen plant is adjusted to produce foamed bitumen with optimum properties, as determined in section A.2. An anti-stripping agent may be added to the bitumen to enhance bitumen adhesion to the aggregate.

Mix each 10 kg aggregate batch according to the following procedure:

Place the entire batch (10 kg) in the mixing bowl. Sufficient moisture should be added so that the moisture content plus the added binder content will be equal to the optimum moisture content, as determined from the moisture/density test described in section A.3. The mechanical mixer should be positioned so that the foamed bitumen can be discharged directly into the mixing bowl. Mix the aggregates and moisture in the mixer for one minute. Without stopping the mixer, discharge the required mass of foamed bitumen into the mixing bowl. Continue mixing the foamed bitumen into the moistened aggregate for a further 30 seconds. Transfer the aggregate treated with foamed bitumen to a sealed container. Repeat this procedure to obtain five samples of foamed bitumen treated material at different bitumen contents. These samples are now ready for further testing.

A.5 Moisture and Bitumen Contents

Take duplicate samples from each batch for moisture and bitumen content checks. Dry to constant mass at 105° C to 110° C and determine the moisture content of the material. Carry out a binder content determination (refer to Method C7, TMH1)

A.6 Procedure for Compaction of Foamed Asphalt Specimens

Clean the mould, collar baseplate and face of the compaction hammer. Place a plastic or paper disc at the bottom of the mould. Weigh out sufficient material to achieve a compacted height of $63,6 \pm 1,5$ mm (usually about 1,15 kg is sufficient). Poke the mixture with a spatula 15 times around the perimeter and poke the rest of the surface 10 times leaving the surface slightly rounded.

Compact the mixture by applying 75 blows with the compaction hammer. Care should be taken to ensure that the hammer can fall freely. Remove the mould and collar from the pedestal, invert it, replace it and press it down so that it rests firmly on the baseplate. Then compact the briquette with another 75 blows.

A.7 Curing

After compaction, remove the mould from the baseplate and allow the specimen to cure for 24 hours in the mould at ambient temperature before extruding it by means of an extrusion jack or other means. Measure the height of the specimen.

The samples should then be cured for a further 72 hours at 60° C in a forced draft temperature controlled oven. The specimens should be placed on a flat smooth surface during curing as well as after curing.

A.8 Bulk Relative Density

The bulk relative density of each briquette (refer to Method C3, TMH1) should be checked after they have cooled to ambient temperature. Exclude from further testing any briquettes whose bulk

relative density differs from the mean bulk density of the batch by more than 30 kg/m³.

A.9 Determination of Indirect Tensile Strength

The standard indirect tensile strength test (refer to TMH1) is used to test compacted, cured foamed asphalt samples under dry and soaked conditions. The indirect tensile strength is determined by measuring the ultimate load to failure of a specimen which is subjected to a constant deformation rate of 50,8 mm / minute on its diametral axis.

Compact and cure test specimens as described in sections A.6 and A.7. Leave the briquettes overnight at room temperature before testing. Measure the height of each briquette at four evenly spaced places around the circumference and calculate the average height, L (m). Measure the diameter of each specimen, D (m).

Place the test briquettes in the air cabinet at 25° C ± 1° C for at least 1 hour but for not longer than 2 hours before testing. Remove a specimen from the air cabinet and place it into the loading apparatus. Position the sample such that the loading strips are parallel and centred on the vertical diametral plane. Place the transfer plate on the top bearing strip and position the assembly centrally under the loading ram of the compression testing device. Apply the load to the specimen without shock at a rate of advance of 50,8 mm per minute until the maximum load is reached. Record this load, P, accurate to 0,1 kN

In order to determine the indirect tensile strength of soaked samples, the following should be done prior to testing : Place the cured specimen in the vacuum desiccator, cover with water at 25° C ± 1° C. Apply a vacuum of 50 mm of mercury for 60 ± 1 minutes, with the timing period commencing once the required vacuum has been reached. Remove the specimen, surface dry and test for the ultimate indirect tensile load as described in the preceding paragraph.

Calculate the Indirect Tensile Strength (ITS) for each specimen to the nearest 1 kPa using the following formula:

$$ITS \text{ (kPa)} = \frac{2P}{\pi LD}$$

Where :ITS = indirect tensile strength (kPa)
P = maximum applied load (kN)
L = length of specimen (m)
D = diameter of specimen (m)

A.10 Determining the Design Binder Content

Plot a graph of the measured indirect tensile strengths versus binder content for all the samples (soaked and dry tests) on the same set of axes. The binder content at which the soaked ITS is at its maximum is taken as the Design Binder Content for the foamed asphalt mix.

A.11 Determining additional mix properties at the Design Binder Content

If required, additional tests such as resilient modulus and dynamic creep tests, may be performed on samples at the design binder content. These would possibly be required for the structural design of the foamed asphalt layer. Additional samples would have to be compacted and cured for this purpose, as described in sections A.6 and A.7.

APPENDIX B : Laboratory Test Results

Table B1: Tests on briquettes

Sample number	Binder content(%)	MTRD	Wet density	Dry density	% Air Voids	ITS dry (kPa)	ITS wet (kPa)	Res. Mod dry (MPa)	Res. Mod wet (MPa)	Strain at break (%)	Creep modulus
A3-2	2.8	2.476	1.828	1.816	26.7		131.100		533.00	1.40	
A3-3	2.8	2.478	1.820	1.809	27.0		129.900		465.00	1.43	
A3-4	2.8	2.495	1.769	1.766	29.2	164.400		741.50		0.80	
A3-5	2.8	2.507	1.773	1.772	29.3	156.300		760.86		0.92	
A3-6	2.8	2.476	1.763	1.761	28.9	147.200		703.31		1.03	
A4-1	3.5	2.478	1.811	1.798	27.5		193.700		723.00	2.19	
A4-2	3.5	2.475	1.786	1.774	28.3		182.200		685.00	1.72	
A4-3	3.5	2.450	1.790	1.785	27.2		189.600		746.00	2.40	
A4-4	3.5	2.443	1.812	1.807	26.1	158.000		598.90		1.14	
A4-5	3.5	2.455	1.826	1.825	25.7	161.400		829.94		0.93	
A4-6	3.5	2.455	1.811	1.809	26.3	178.400		769.29		0.73	
A4-7	3.5	2.430	1.806	1.804	25.8	169.500				0.86	
A5-1	5.0	2.435	1.797	1.792	26.4		207.800		657.00	2.40	
A5-2	5.0	2.480	1.780	1.769	28.7		156.100		624.00	2.51	
A5-3	5.0	2.453	1.780	1.765	28.0		229.000		773.00	1.54	
A5-4	5.0	2.432	1.789	1.787	26.5	164.500		725.10		1.14	
A5-5	5.0	2.425	1.791	1.787	26.3	180.100		732.63		1.38	
A5-6	5.0	2.408	1.789	1.785	25.8	137.400		564.31		1.09	
A3	3.4	2.403	1.776	1.774	26.1	119.000				0.67	
A4	3.4	2.498	1.726	1.723	30.9	106.500		278.90		0.97	
A5	3.4	2.426	1.727	1.724	28.8	105.200		610.90		0.88	
A6	3.4	2.405	1.728	1.726	28.1	122.500		825.30		0.63	
A7	3.4						148.600			1.37	
A8	3.4						115.800		456.50	0.82	
A9	3.4										
A10	3.4										
B3-1	2.4	2.541	2.138	2.130	16.2		356.582		936.66	1.28	
B3-2	2.4	2.555	2.118	2.113	17.3		337.592		967.89	1.19	
B3-3	2.4	2.544	2.102	2.096	17.6	445.274		1353.70		0.82	
B3-4	2.4	2.547	2.112	2.105	17.4		343.919		880.85	0.92	
B3-5	2.4	2.560	2.113	2.109	17.6	410.138		1260.77		0.96	
B3-6	2.4	2.536	2.069	2.063	18.7	387.671		1120.91		0.74	
B4-1	3.6	2.513	2.118	2.110	16.0		396.592		1098.40	1.35	
B4-2	3.6	2.501	2.099	2.093	16.3		406.647		1088.14	1.38	
B4-3	3.6	2.522	2.112	2.106	16.5	387.300				0.77	
B4-4	3.6				16.4		356.225			1.28	
B4-5	3.6	2.526	2.099	2.095	17.1	439.106		1265.72		0.94	
B4-6	3.6	2.504	2.110	2.106	15.9	432.756		1241.47		0.81	
B4-7	3.6	2.498	2.097	2.091	16.3						
B5-1	4.4	2.487	2.078	2.070	16.8		441.713		1135.22	1.77	
B5-2	4.4	2.487	2.099	2.091	15.9		430.280		1147.00	1.33	
B5-3	4.4	2.473	2.064	2.058	16.8	441.831		1294.17		0.91	
B5-4	4.4	2.474	2.047	2.043	17.4		423.660		988.83	1.45	
B5-5	4.4	2.484	2.038	2.030	18.3	423.315		1203.51		0.76	
B5-6	4.4	2.486	2.051	2.048	17.6	413.755		1316.57		0.69	
B3	3.6	2.502	2.172	2.169	13.2	592.400				0.49	
B4	3.6	2.490	2.146	2.144	13.8	461.900		1531.80		1.00	
B5	3.6	2.542	2.144	2.142	15.7	561.100		1750.90		0.64	
B6	3.6	2.495	2.156	2.154	13.6	501.500		1603.00		0.49	
B7	3.6						263.200			0.72	
B8	3.6						192.300		638.60	0.97	
B9	3.6						158.800		610.10	1.87	
B10	3.6						176.300		549.60	1.36	
B1	3.6										471.43
B2	3.6										550.00
C4-1	3.0	2.504	2.058	2.050	18.1		324.025		966.84	1.16	
C4-2	3.0	2.494	2.074	2.064	17.3		307.004		860.47	0.98	
C4-3	3.0	2.505	2.032	2.024	19.2	567.614		1418.01		0.44	
C4-4	3.0	2.503	2.050	2.041	18.5		334.718		946.72	1.99	
C4-5	3.0	2.478	2.011	2.002	19.2	542.849		1314.65		0.33	
C4-6	3.0	2.474	2.108	2.099	15.1	551.513		1264.66		0.58	
Sample	Binder	MTRD	Wet	Dry	% Air	ITS	ITS	Res. Mod	Res. Mod	Strain at	Creep

number	content(%)	density	density	Voids	dry (kPa)	wet (kPa)	dry (MPa)	wet (MPa)	break (%)	modulus
C5-1	3.9	2.460	2.050	2.049	16.7	329.586		931.58	0.85	
C5-2	3.9	2.462	2.133	2.127	13.6	335.996		941.07	1.14	
C5-3	3.9	2.490	2.011	2.004	19.5	395.860			0.66	
C5-4	3.9	2.488	2.108	2.100	15.6	356.778			1.59	
C5-5	3.9	2.459	2.133	2.126	13.5	532.402	1214.32		0.50	
C5-6	3.9	2.459	2.059	2.051	16.6	498.915	1365.17		0.97	
C5-7	3.9	2.467	2.057	2.052	16.8	549.774	1249.23		0.50	
C6-1	5.5	2.446	2.037	2.029	17.0	372.221		967.70	1.16	
C6-2	5.5	2.457	2.059	2.054	16.4	288.645		675.65	1.94	
C6-3	5.5	2.387	2.020	2.018	15.4	566.404	1378.27		0.49	
C6-4	5.5	2.494	2.057	2.049	17.8	410.040		854.05	1.08	
C6-5	5.5	2.376	1.995	1.991	16.2	546.474	1205.62		0.75	
C6-6	5.5	2.433	2.007	2.003	17.7	500.287			0.77	
C3	3.6	2.419	2.080	2.078	14.0	656.400			0.41	
C4	3.6	2.338	2.076	2.074	11.2	502.200	1341.50		0.94	
C5	3.6	2.368	2.106	2.104	11.1	592.400	1610.80		0.46	
C6	3.6	2.378	2.066	2.063	13.1	522.800	1481.10		0.63	
C7	3.6					199.600			1.31	
C8	3.6					112.800		327.20	2.26	
C9	3.6							269.30		
C10	3.6					95.300		250.10	3.25	
C1										413.33
C2										58.25

Table B2: Bending Beam Tests

Sample number	Binder content(%)	Peak Stress (MPa)	Strain1 (µε)	Strain2 (µε)	Avg E-Mod (MPa)
b1	3.60	0.74	445.28	496.48	1569.41
b3	3.60	1.79	803.70	765.99	2283.25
b4	3.60	2.00	533.70	594.20	3544.65
b5	3.60	0.52	364.74	412.95	1339.87
b6	3.60	0.56	323.69	343.60	1684.43
c1	3.60	1.12	552.65	613.12	1914.62
c2	3.60	1.02	205.27	225.39	4755.51
c3	3.60	1.45	584.22	553.22	2553.11
c4	3.60	1.42	696.33	663.55	2086.95
c5	3.60	0.68	107.36	371.97	2837.27
c6	3.60	0.68	271.59	280.55	2448.66

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W Western S Stabilization Foamed Asphalt

COLD FOAM IN IN PLACE RECYCLING (CFIPR)

CFIPR utilizes foamed asphalt. Foamed asphalt is a mixture of aggregates stone and soil (recycled road) and foamed bitumen (paving oil). The bitumen is foamed by an innovative process, harnessing the usually undesirable reaction which occurs when hot bitumen is combined with water.

In order to mix bitumen with road-building aggregates, you first need to considerably reduce the viscosity of the cold hard binder. Traditionally, this was done by heating the bitumen and mixing it with heated aggregates to produce hotmix asphalt. However the foamed asphalt process is one of introducing moisture into a stream of hot bitumen, which effects a spontaneous foaming of the bitumen (similar to spilling water into hot oil). In the foamed state the bitumen has a very large surface area and extremely low viscosity making it ideal for mixing with aggregates.

The foamed asphalt is introduced simultaneous to the road recycling in a "one pass" process utilizing a Wirtgen WR2500 or WR3000 equipped with a foamed asphalt system.

This presentation will give you a relatively quick overview of how the foamed asphalt process works, and will certainly raise some questions. Please view this presentation, and we will be happy to answer all of your questions.

STRUCTURAL DESIGN LIFE

Asphalt concrete layers fail in fatigue – layers of unbound material fail due to shear/consolidation. Mechanistic design predicts the number of load repetitions to failure (ESAL's).

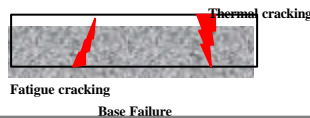
Considerations:

Percent of Trucks

Site Considerations (existing failures, water table)

Economics — relative to alternatives

Mode of failure for roadways constructed with asphalt concrete and base



The foamed asphalt Process is an engineered process utilizing a mix design determined by a lab after extensive testing. Here are some examples of how the mix design is created.

Field Investigations

Surveys / Tests provide an understanding of the existing pavement structure in order to derive maximum benefit from its intrinsic value.

- Test pit excavation to examine the existing pavement structure, soil profile and to obtain samples for laboratory testing
- Coring to verify existing AC thickness
- Dynamic Cone Penetrometer (DCP) survey to determine the in-situ material strength properties
- Deflection tests

EXPLORATORY TEST PITS

Test Pits are typically 24 inches by 36 inches, and 36 inches deep.
Two test pits are dug for each mile of roadway recycled.



STRUCTURAL SECTION/SOIL PROFILE



CORING

Coring provides verification of existing asphalt concrete thickness and nature of underlying material

Coring provides access points for Dynamic Cone Penetrometer (DCP)

Cores are taken every 500 yards
one in the wheel path
one at the center of the lane



DCP

Dynamic Cone Penetrometer is used to determine in-situ strength of base and sub-base or native material

DCP verifies test pit, and provides an indication of continuity of structural section.



In some cases the engineers determine that the mix design requires a chemical additive such as lime or cement. The addition of these “make up” materials can be done over the existing road prior to recycling.



This is an engineered process and requires some extensive site testing to create a mix design. Therefore it's necessary to have a machine capable of pulverizing to the depth required by the mix design and precisely control the rate of foam being introduced into the pulverized material in relation to the rate of travel.

Keeping all of this in mind, and after extensive research, Western Stabilization has reached the conclusion that the Wirtgen series of recyclers/foamed asphalt machines are best suited for the task.

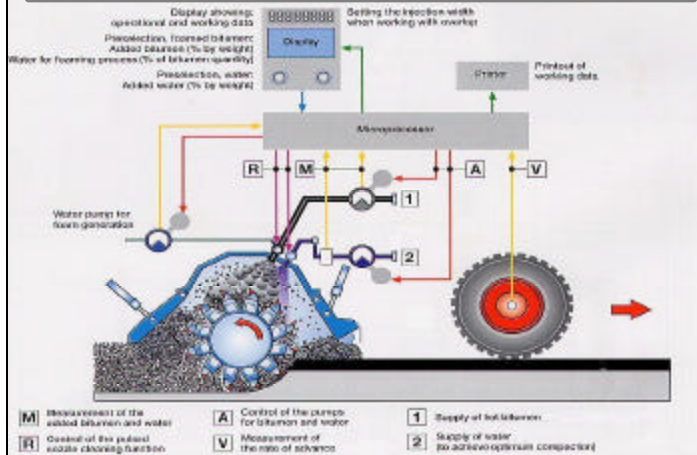
This is our Wirtgen WR3000 Recycler. It has a 10 foot wide recycling drum that can pulverize up to 18 inches deep. We also have a WR2500 that has an 8 foot drum



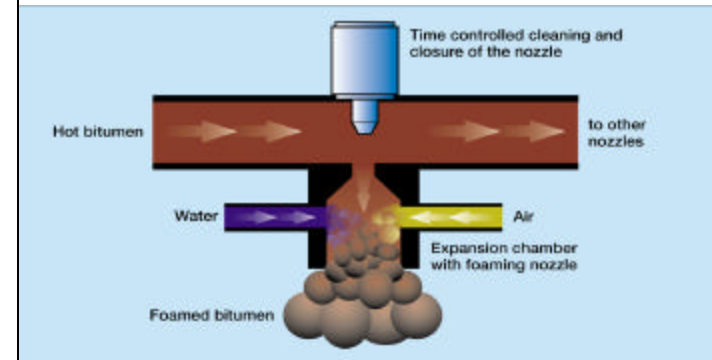
This is the drum for our WR3000 it is 10 feet wide, 58 inches tall, and has 276 replaceable carbide teeth



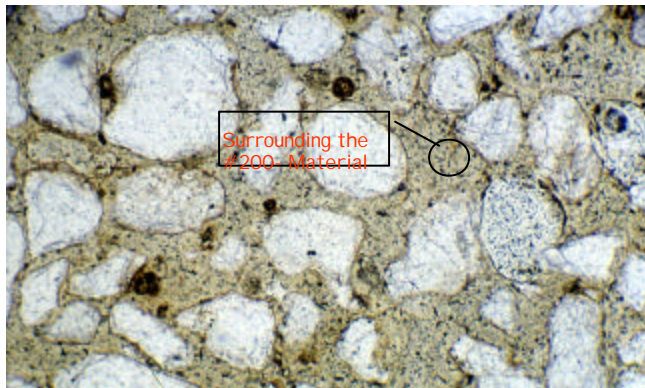
While the existing road is being pulverised to a pre determined depth the foamed asphalt is simultaneously being introduced at a rate specified by the mix design. This process is precisely controlled by an onboard computer system.



Both the Wirtgen WR2500 and WR3000 are equipped with a microprocessor controlled foam spray bar with 16 individual nozzles and 16 individual expansion chambers insuring even distribution of foam throughout the process.



This is a magnified cross section of a Marshall Briquette. The Foamed Asphalt creates a “Brick and Mortar” effect. It attaches to the minus 200 fines to create the mortar binding the larger aggregates together. It doesn’t coat the aggregates.





FINAL GRADING & COMPACTION



FINISH ROLLING OPERATION (Slushing)

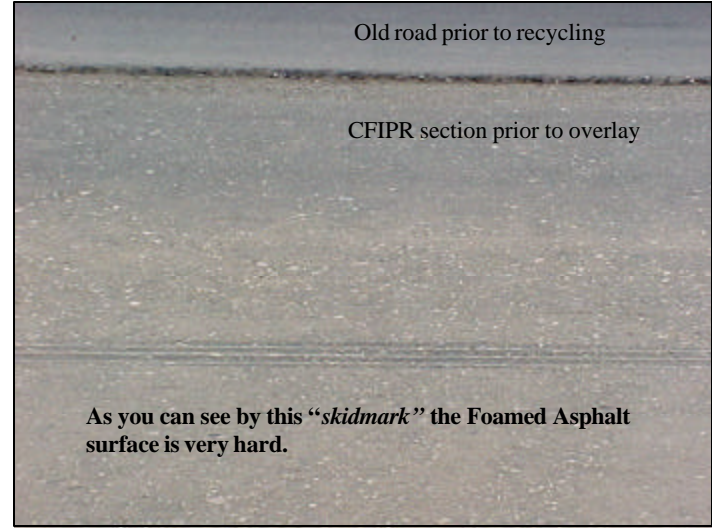


FINISH ROLLING OPERATION (Slushing)



FINAL SWEEPING (ready for traffic)





Economics

Option 1: 3 inch Overlay with digouts

3 inch overlay cost: \$9.63 per square yard

3 inch digouts over 15% of roadway cost: \$2.52 per square yard

Cost per lane mile: \$83,520.00

Estimated service life: 5 years

Economics

OPTION 2: 4 inch Overlay with digouts

4 inch overlay cost: \$11.37 per square yard

3.5 inch digouts over 20 % of roadway cost: \$4.93 per square yard

Cost per lane mile: \$112,320.00

Estimated service life: 8-10 years

Economics

Option 3: 2 inch overlay with C.F.I.P.R.

2 inch overlay cost: \$6.27 per square yard

9 inch C.F.I.P.R. cost: \$6.35 per square meter

Cost per lane mile: \$87,200.00

Estimated service life: 10-12 years

Virtually no maintenance for 6-8 years

Economic Comparison

Option 1:(3 inch overlay) cost \$83,520.00, service life 5 years
\$10,400.00 per year of service life

Option 2:(4 inch overlay) cost \$112,320.00, service life 8-10 years
\$7,800.00 per year of service life

Option 3:(CFIPR) Cost: \$87,200.00, service life 10-12 years
\$4,954.00 per year of service life
Virtually no maintenance for 6-8 years

WHY COLD FOAM

Once compacted it can be trafficked immediately

No loose surface material (reduces risk of cracked windshield liability)

Eliminates repeat digouts due to existing base failure

Eliminates reflective and reduces thermal cracking

Resistive to moisture intrusion into the base

Achieves strengths similar to a comparable section of full depth AC

Virtually no maintenance for 6 to 8 years

Simultaneous addition of "make up" material

Makes maximum benefit of materials by recycling existing pavement

Cost savings (typically 1/2 the cost of conventional reconstruction)

Speed of construction (typically 1/2 the time of conventional reconstruction)

Virtually no maintenance for 6 to 8 years

The Candidate Roadway

Prior Distress

Base failure in the wheel paths

Alligator cracking

Transverse cracking

Thermal cracking

Longitudinal cracking

If you have any roads in your jurisdiction that resemble these, we're certain that we can save you considerable time and money.



Western Stabilization has successfully completed nearly 30 road recycling jobs utilizing the Foamed Asphalt process totaling over 7 million square feet. Here is a description of a few recent jobs.

August 2002, 205,000 Sq. Ft. Residential street for the City of Marysville, John Mallen.

September 2002, 160,000 Sq. Ft. Residential street with curb and gutter for the City of Davis, Nancy Mckee

October 2002, 5 Acre composting pad for B&J Landfill, Greg Pryor.

May 2002, 87,000 Sq. Ft. City street for the City of Chico, EC Ross.

July 2002, 1,200,000 Sq. Ft. State Hwy. 89 For CalTrans, Joe Peterson.

July 2002, 1,044,000 Sq. Ft. County Road for Yuba County, Kevin Mallen.



The logo for Western Stabilization Foamed Asphalt features a large, stylized 'W' and 'S' in red and white. To the right of these letters, the words 'Western Stabilization' are written in a bold, black, sans-serif font. Below this, the words 'Foamed Asphalt' are written in a large, white, 3D-style font with a black outline. At the bottom of the logo, contact information is provided in a smaller, black, sans-serif font.

Please contact: Paul Jones Office (707) 678-0369
Mobile (209) 4561125
E-Mail: pjones@wstabilization.com

Driving Surface Aggregate (DSA): Developed by Penn State's Center for Dirt and Gravel Road Studies, DSA is a mixture of crushed stone developed specifically as a surface wearing course for unpaved roads. DSA has a unique particle size distribution designed to maximize packing density and produce a durable road surface that performs better than conventional aggregates.



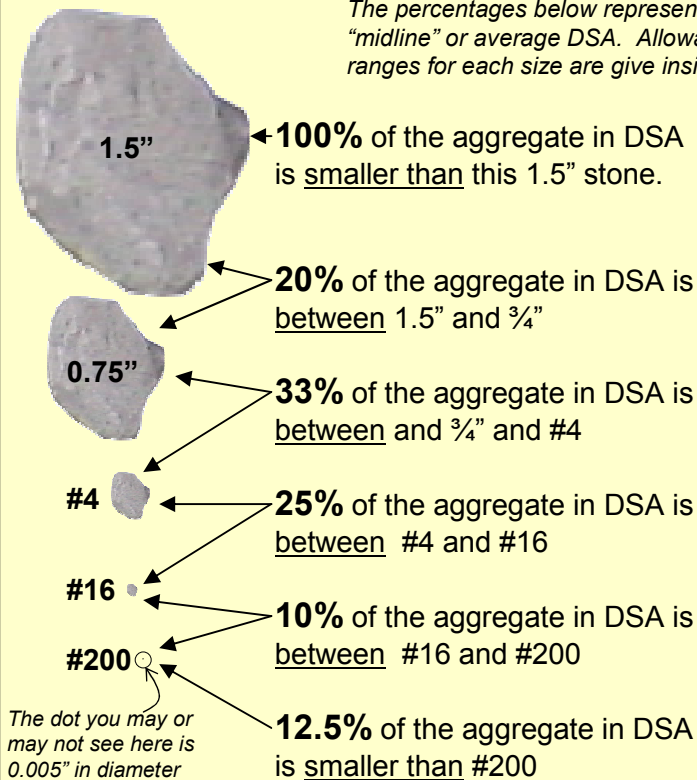
Figure 1: Placement of DSA through a paver.

Inside the DSA: Larger particles locked tightly in place by smaller particles and fines.



DSA Components, ACTUAL SIZE

The percentages below represent a "midline" or average DSA. Allowable ranges for each size are give inside.



The above illustration shows how the various size components of DSA lock together when compacted to produce the most dense and durable surface possible. The specification is well graded from large pieces that give support, all the way down to the "fines", rock particles less than 1/200th of an inch. This well graded mix including fines allows DSA to achieve a very high density. The box to the left illustrates the actual sizes of a "midline" or average DSA specification.

DSA Key Facts:

- Designed for maximum compacted density;
- Contains 10%-15% "minus #200" fine material;
- Fine material is crushed rock, not silt or clay;
- Must be delivered at "optimum moisture";
- Should be placed using a motor-paver;
- Should be compacted with 10-ton vibe roller;
- Can be placed at in an 8" depth and compacted to 6", or in a 6" depth and compacted to 4½";
- As of 2006, DSA is a PENNDOT approved aggregate in publication 447 (MS-0450-0004).

DSA Purchasing

All Driving Surface Aggregate (DSA) is to be derived from natural stone formations. For use in this program, aggregate sources are restricted to that which has been mined or quarried from existing geologic bedrock formations. Ninety-eight percent (98%) of fines passing the #200 sieve must be rock material. No clay or silt soil may be added. Limestone material passing the #200 sieve may be used to make up a deficit in the distribution of sandstone aggregate rock, and vice versa. All added material passing the #200 sieve must be derived from rock material that conforms to program specifications. Lime kiln dust and cement kiln dust may be added to DSA to account for up to 50% of the fines passing the #200 sieve. The amount of particles passing the #200 sieve shall be determined using the washing procedures specified in PTM No. 100.

- **Size:** The required sizes and allowed ranges, determined by weight, for various size particles are shown in Table 1.
- **LA Abrasion:** The acceptable hardness as measured by weight loss is “less than 40% loss”. Los Angeles Abrasion test, AASHTO T-96 [ASTM C 131] shall be used to determine this property. Existing data from tests made for and approved by PENNDOT will be accepted.
- **pH:** Aggregate must be in the range of pH 6 to pH 12.45 as measured by EPA 9045C.
- **Optimum Moisture:** Material is to be delivered and placed at optimum moisture content as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, procedure C, Standard.
- **Transport:** Tarps are to be used to cover 100% of the load’s exposed surface from the time of loading until immediately before dumping. This requirement includes standing time waiting to dump.

Sieve Size	Percent Passing
1.5"	95 – 100
0.75"	65 – 95
#4	30 – 65
#16	15 – 30
#200	10 – 15

Table 1. DSA size gradation.

Aggregate producers are required by the program to certify that the aggregate they deliver conforms to the Program specifications (See DSA Certification and Specification document). A new certification is required for each project, or whenever the source of aggregate changes.

How much DSA should I order?			
DSA Needed = (tons)	Road Width x (ft)	Road Length x (ft)	0.038 for 8" loose compacted to 6"
			0.029 for 6" loose compacted to 4½"

Note factors have been slightly reduced in 2009 based on field experience.

Preparation for DSA Placement

The Driving Surface will reflect the shape of the road base.

1. Prepare subsurface drainage, including drain tile, French drains (porous fill), and crosspipes where necessary.
2. Address surface drainage structures, such as broad-based dips, grade breaks, crown, and side-slope.
3. Establish proper drainage in existing base (*figure 2*). Recommended crown or cross-slope is ½ to ¾ inch per horizontal foot. Proper shape may be a flat “A” crown profile, an in-slope or out-slope. If exposed bedrock or insufficient material prevents proper shaping of the road base, additional base material should be added before aggregate placement.
4. For tightly packed existing road surfaces, it is important to scarify the road surface so the DSA will bind better with the base layer.
5. If required, class 2A separation fabric should be evenly placed according to manufacturer’s recommendations.
6. A 3”-4” “key” should be cut along the existing road edge when grading. DSA should be placed against this key to support the aggregate edge, prevent a large drop-off, and facilitate compaction.

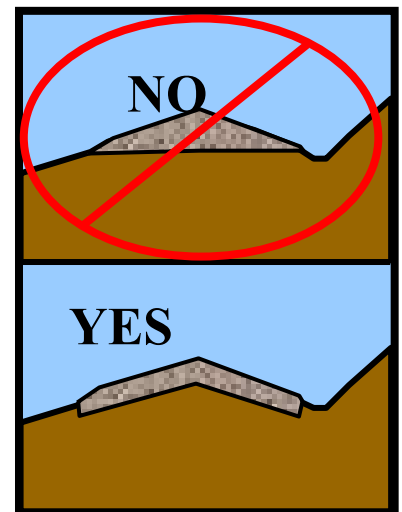


Figure 2. Road base preparation.

DSA Placement

An un-compacted uniform depth of 6 to 8 inches of DSA is to be used to establish the driving surface (*figure 3*). Placement is to be in a single lift. The preferred method of application is through a paver. Set the paver adjustments on application thickness and width so it is unnecessary to use a grader. The required crown or side slope is $\frac{1}{2}$ " to $\frac{3}{4}$ " rise per horizontal foot. This slope is to be achieved by properly preparing base and placing aggregate in a uniform lift (*figure 2*). When the paver is applying aggregate, care should be taken to keep the paver at or near capacity at all times. To fill driving surface areas outside the specified width (e.g. driveway entrances, pull-offs, and passing lanes), additional DSA is to be added and tapered to grade or butted against a precut channel of the same depth. If berm or bank edges don't exist to hold the new DSA surface, then sufficient material is to be placed, tapered, and compacted to form protective edge berms. Individual projects can be placed at either 8" or 6" depth. Factors such as traffic volume, traffic weight, and available budgets play a role in determining aggregate depth. 8" aggregate placements will provide more material to re-work into the road over time, while 6" placements will allow a longer length of road to be surfaced.

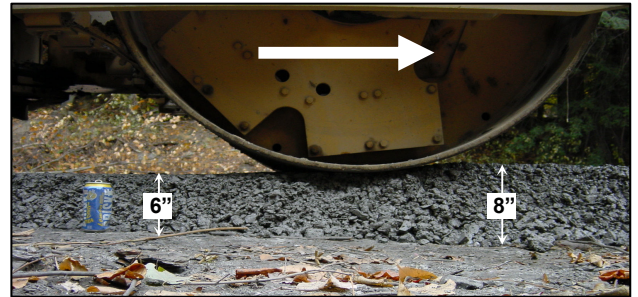


Figure 3: A roller moving from left to right compacts the 8" lift of loose DSA down to 6".

DSA Compaction

Verify that moisture is optimum for compaction. If the material has dried out, re-wet the DSA surface with a water truck. If clumps of aggregate adhere to the roller drum, the aggregate may be too moist. Allow drying time before rolling. Do not use the vibratory rolling mode if that action brings water to the surface of the aggregate.

- 1A. **SUPPORTED EDGE:** *If edge of placed aggregate is supported by an existing bank or berm:* First pass: Roll slowly in static mode on the outside edge of placed aggregate.
- 1B. **UNSUPPORTED EDGE:** *If the edge of the placed aggregate is not supported:* First Pass: Roll slowly in static mode near but not over unsupported outside edges. Once that path is firm, move progressively closer to the outside edge with static passes until unsupported edge is firm.
2. **SEQUENCE:** As in all rolling operations, compaction is achieved making overlapping lengthwise passes beginning at the ditch or berm-side and working toward the crown or the top edge. In no case should the roller be run lengthwise on the top of the road crown.
3. **VIBRATORY ROLLER:** A minimum 10 ton vibratory roller should be used at a speed of approximately 2-3 miles per hour. The initial pass over un-compacted aggregate should be completed in static mode. All successive passes should be made in vibratory mode. The final pass over each area should be made in static mode to remove all roller edge marks. Vibration should be turned off during steep downgrade passes to prevent creating a "wave" of aggregate movement in front of the roller.
4. **DESIRED COMPACTION:** Unless compaction testing equipment is available (see last page), adequate compaction is indicated when no further depressions are created with a roller or loaded dump truck. Cracking of larger stones in the road surface is another indication of adequate compaction.

DSA Maintenance

DSA provides a durable road surface with longer maintenance cycles but it is not maintenance free. DSA is a different type of material requiring a different maintenance approach:

- Because uniform distribution of particle sizes is critical, loosening DSA to sufficient depth during grading operations is very important to reestablish the proper blend of particle sizes and achieve maximum compaction density. The use of a "carbide-tipped grader blade" may be necessary for maintenance grading. See Center's related technical bulletins.
- Optimum moisture content is essential during DSA maintenance operations. DSA dries out quickly and is prone to separation under dry conditions. Damp drizzly conditions are ideal for maintenance grading.
- In order to preserve the environmental benefits of DSA, care should be taken to avoid mixing material pulled out of the ditches with the surface material during grading.

Insuring Quality Aggregate

An ounce of prevention is worth a pound of cure. To insure aggregate quality, it is recommended to visit and work with the quarry prior to aggregate placement. You may want to consider using an independent lab to test the aggregate to insure it will perform as expected. When considering an independent laboratory for analyzing the DSA material, there are two recommended tests:

- **The Sieve Analysis with Wash**, (~\$130) shows the percentages of the material passing the five sieve sizes. These gradations should fall within the corresponding specification range for each sieve size.
- **The Standard Proctor Analysis**, (~\$145) determines the optimum moisture and maximum density for the specific material. Using this information, on-site compaction testing can be conducted by a lab technician, (~\$50/hour). Information obtained from the Proctor analysis is used to calibrate a Nuclear Density Meter in the field (*figure 4*). Maximum densities of 95% or better (of theoretical maximum density determined during proctor test) should be realized on the aggregate in the field.
- If there are concerns about the type of material in the DSA, a Hydrometer test (particle size analysis), (~\$140) is also recommended. This test will determine the percentages of gravel, sand, silt, and clay in the aggregate.
- The cost of testing from the independent laboratory and related on site compaction testing can be included in the grant application under “Project Expenditures” for Dirt and Gravel Road Program Projects. When spending \$10,000 to \$40,000 on DSA, the ~\$500 in up-front testing seems like a bargain compared to dealing with bad stone!



Figure 4: A Nuclear Density Meter calculates density and moisture.

Other Considerations

- As of 2006, DSA is approved for purchase by PENNDOT, and can be purchased by townships using Liquid Fuels Money. See PENNDOT publication 447 (MS-0450-0004) for details.
- DSA Parent material may be limestone, sandstone, or any other natural stone that meets the standards.
- DSA can be placed directly onto separation fabric if needed. The use of separation fabric in wet areas will stabilize the road base and lead to better long term aggregate performance.
- **Dirt and Gravel Road Program Notes:**
 - PA's Dirt and Gravel Road Program does NOT require the application of surface material on funded projects. However, if a surface material is applied, DSA is the only Program-approved material.
 - The use of fabric and dust suppressants is allowed, but not required on Program projects.
 - DSA placement using a paver is strongly encouraged, especially on larger projects. Mobilization costs may preclude the use of a paver for short projects with small quantities of DSA.
- **Environmental Benefits:**
 - Preliminary studies completed by the Center have shown a 80-90% reduction in sediment runoff from DSA compared to existing road surfaces, even after 3 years of exposure and use.
 - Because DSA is so densely packed, less loose material is available to generate dust. Dust generation and dispersal is also reduced because the fines in DSA are crushed rock, not silt or clay.
 - DSA further reduces dust and sediment pollution by lengthening road maintenance cycles. Road maintenance loosens the aggregate surface, resulting in periods of increased dust and sediment loss.
- **DSA Recipe:** While many quarries can make DSA through their crushing and screening process, it is also possible to mix some commonly available aggregates to create DSA. This mixing process can be accomplished with a front end loader and a water source. →
- Many other technical documents about DSA such as certification and maintenance practices can be found under “resources” at www.dirtandgravelroads.com.

A “Recipe” for DSA:

8 parts PENNDOT 2A
+
1-1.5 parts PENNDOT #57
+
1 part “minus #200” fines

NOTE: Because the gradations used have a range, the recipe shown here may differ slightly. For this reason, it is important to conduct a sieve analysis after mixing to insure that the DSA gradation in Table 1 is met.

SECTION 02726

UNPAVED ROAD SURFACING AGGREGATE (Driving Surface Aggregate – DSA)

PART 1 GENERAL

1.1 DESCRIPTION

- A. The work of this section consists of furnishing and delivering surfacing aggregate to the Schonchin Butte Road within Lava Beds National Monument, Siskiyou County, California. Work includes testing the material to determine optimal moisture content for proper (90-95%) compaction.

1.2 SUBMITTALS

- A. Two copies of certified weight tickets for each load of aggregate delivered to project site.
- B. Certification from the supplier certifying that aggregate base course meets the requirements of this section.
- C. Test results using Proctor Test ASTM D698, procedure C, Standard showing optimum moisture content as determined for that particular aggregate source.

PART 2 PRODUCTS

2.1 AGGREGATE

- A. Clean, hard, durable fragments or particles of crushed stone. Materials that break up due to freeze-thaw or wet-dry cycling shall not be used.
 - 1. Coarse Aggregate: Los Angeles Abrasion test, AASHTO T-96 (ASTM C 131) shall be used to determine this property. The acceptable limit as measured by weight loss is “less than 40% loss”.
 - 2. Size: The required amounts and allowed ranges, determined by % weight, for various size particles are shown on page 1 of this certification.

Sieve Size	Percent Passing
1-1/2-inch	100
¾-inch	65 - 95
No. 4	30 - 65
No. 16	15 – 30
No. 200	10 - 15

- 3. Minus #200 Composition: Ninety-eight percent (98%) of fines passing the #200 sieve must be rock material. No clay or silt soil may be added. All added material passing the #200 sieve must be derived from rock material that conforms to program specifications.

Lime kiln dust or cement kiln dust may be added to DSA to account for up to 50% of the fines passing the #200 sieve.

4. Optimum Moisture: Material is to be delivered containing optimum moisture content as determined for that particular aggregate source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, procedure C, Standard. Compaction shall be 90-95%.
5. Weed free Materials: Aggregate materials shall be free of noxious weeds or seeds and from an established commercial source that has been certified weed free. If a contractor chooses to use a non-certified source, notify the Contracting Officer 14 days prior to proposed delivery to allow for a source inspection by a National Park Service botanist or biologist. In the event weed contamination is discovered, the material source may be found unsuitable for use.
6. Transport: Tarps are to be used to cover 100% of the load's exposed surface from the time of loading until immediately before dumping. This requirement includes standing time waiting to dump.

PART 3 EXECUTION

3.1 DELIVERY

1. Aggregate shall be delivered to the project road, on weekdays only. NO deliveries may occur on Federal holidays. Aggregate shall be delivered in end dump trucks dumping into a self propelled paving machine. National Park Service staff and equipment shall place, grade and compact the aggregate on the roads. Delivery of aggregate shall be at a minimum rate of 600 tons per day and a maximum rate of 800 tons per day.
2. Aggregate delivery may not occur on days when substantial rain is predicted. The Contracting Officers Representative (COR) will determine after consulting the weather prediction at the close of each business day if delivery should occur on the following day. The COR will contact the contractor at the close of each business day if deliveries are to be canceled the next day due to predicted rain. If substantial rain occurs unexpectedly during the day, deliveries may be terminated during the work day.
3. Aggregate delivery trucks shall enter and exit Lava Beds National Monument via the North (Hill Road) or the Northeast (Dike Road) Entrances. Due to poor pavement conditions, delivery trucks may not enter or exit the National Monument via the Southeast (Tionesta/ Modoc National Forest Route 10 Road) or the Medicine Lake Road (Modoc National Forest Route 49) Entrances.

PART 4 MEASUREMENT AND PAYMENT

- A. Payment will be made based upon the number of tons, to the nearest tenth of a ton, verified by weight tickets delivered to the specified roads and sites.

END OF SECTION

12/97

02725-2

AGGREGATE BASE COURSE

Fundraiser aims to keep decoy car on the road

Posted: Monday, June 28, 2010 2:00 am

By MELISSA WEAVER/The Daily Inter Lake |

Volunteers are throwing a fundraiser Wednesday for the decoy patrol car that aims to dissuade speeding along U.S. 93.

On June 30 from 5 to 9 p.m., head out to the Tamarack Brewing Co. in Lakeside for a party that aims to raise money to keep operating the patrol car and its mannequin driver, known as Lucky, and buy equipment to increase speed awareness on U.S. 93 along the west shore of Flathead Lake.

“My husband and I brainstormed about the horrible accidents and the people killed, and we were like, ‘Other towns had done it, surely we could do this,’” said Deb Newell, explaining her rationale for asking Lake County Sheriff Lucky Larson to donate a retired patrol car to encourage motorists to drive more safely.

Newell said her friends wanted to help out, and the volunteer organization called Saving Lives On the West shore was born.

Every day, SLOW members and their husbands take turns driving Lucky to various locations along U.S. 93, and every night return to take it home so it does not get vandalized.

The decoy also is equipped with a device that alerts people with radar detectors that there is a radar gun in the area.

“Slowing people down and making people aware is an urgent problem,” Jan Kerley of SLOW said.

According to another group member, Cindy Lewis, the stretch between Montana 82 and Dayton is “especially dangerous” for Lakeside residents, and U.S. 93 is Lakeside’s main street.

An elementary school is half a block off the highway and all school buses, parents’ cars and pedestrian traffic have to cross or make turn from the highway to reach the school.

The crosswalk is at the bottom of a steep grade, where traffic must slow from 55 mph to 35 mph in less than half a mile.

Also affected by the heavy summer traffic are busy public docks and a new county park that is being built. Each have parking areas on the opposite side of the highway.

In the last few years, the Somers/Lakeside area has had three fatalities directly related to speeding traffic, according to Newell.

But SLOW members said there have been even more undocumented close calls.

The women said they have been lobbying for years to get the speed limit reduced in the Somers area by meeting with county commissioners, writing letters to the director of the Montana Department of Transportation, keeping Lucky running and actively spreading the word.

They have thus far been successful in lowering the speed limit from 70 mph to 55 mph between Lakeside and Somers.

But a lower limit means nothing if drivers don't heed it.

Lucky's presence "makes people pay attention to the speed limit," said Newell. "A lot of people weren't aware of the issues. But when they were, they were happy to slow down."

Lewis chimed in: "We don't want anyone else to die."

Last year's fundraiser raised \$5,702, enough money for the group to buy insurance, gas, tires and a new battery for Lucky, as well as fix its radar equipment.

This year, SLOW hopes to raise \$7,500, which will go toward general maintenance for Lucky and help to purchase a speed indicator trailer and two radar guns.

At Wednesday's event, 75 cents from every pint sold from 5 to 9 p.m. will be donated. The event also will have a raffle including prizes of an "instant wine cellar," an etching by Barbara Coppock, a watercolor by Gary Spetz and \$100 gift certificates from A Able Fishing Charters and Tours. There also will be door prizes.

For additional event details, visit www.tamarackbrewing.com.

Reporter Melissa Weaver may be reached at 758-4441 or by e-mail at mweaver@dailyinterlake.com.

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North Fork Flathead Road – Improvement Options research summary

Dust Palliatives/Suppressants

Magnesium Chloride – dust suppressant, absorbs water vapor from the air and liquid water from the road bed, keeping moisture in the road. Acts like a salt (keeps the road more muddy in winter), lasts 8-12 wks. “Reactivates” when rained on. Acidic.

Calcium Chloride - absorbs water vapor from the air and liquid water from the road bed, keeping moisture in the road. Sprayed as a diluted solution, one pass will cover an 8- to 12-foot-wide road. Lasts ?? (couldn't find this information, any help from Bill, Ryan or John is appreciated) **Montana Dust Control Co. says this lasts about the same as MgCl, but not as effective in MT weather, so they don't use it, and Flathead County doesn't use it.**

Lignin sulfonate –polymer derived from wood, acts like a salt (keeps the road more muddy in winter). For dust control, can be sprayed directly on the surface. For stabilization, it's mixed with the top few inches of road surface. It's water soluble, environmentally friendly, easy to handle and apply. The surface will still develop potholes, and you'll need to scrape off and remix the top layer after a few months. Takes time for road to cure and harden. Neutral to environment.

Black Oil – asphalt emulsion. Does not last as long as MgCl, price greater (? Found article in newspaper that stated costs are higher than MgCl)

Bentonite – naturally occurring clay with charged particles that are so small they bind to the dust/gravel to reduce dust. Community has health concerns. About half cost of CaCl, One disadvantage of bentonite is its inability to bind with some types of gravel used on some secondary roads – works best with limestone type gravels because of the charge. **Added to the aggregate when placed (not yearly) and then treated at the appropriate frequency with a dust palliative to make it work best. (source: Earl Applecamp FNF)**

Stabilization Treatments

Lignin sulfonate – see description above.

~~*Top Seal* (by SCI) – a liquid soil stabilizer, works by making the surface impermeable. Ready for driving in minutes and strength increases over time. Not much other information available.~~

Told that this is the same as “black oil.” Removed from options list.

RoadOyl – pine resin emulsion, works by keeping water out of the surface. Need a lot of fines to bind, applied as a diluted solution, residual benefits each year, applied above freezing temperatures. Environmentally certified (see website for details on this certification). Traffic compacts the surface into a smooth pavement-like finish. Applications are cumulative, so reapplications should become more dilute and less frequent until the maintenance level is reached. Can react with strong organic oxidizing materials, strong acids and strong bases.

SoilSement – acrylic polymer emulsion, environmentally certified, works by keeping water out of the surface. Need a lot of fines to bind, applied as a diluted solution, residual benefits each year, applied above freezing temperatures. Applications are designed to last 3-6 months. Is environmentally safe, non-toxic, non-corrosive, non-flammable and does not pollute groundwater.

EnviroKleen – polymeric binder (also a resin version, EK35), used non-diluted, binds dust particles together to prevent from escaping – Some question about it actually binding? Can be used in any temperature. More expensive than RoadOyl or SoilSement.

Coherex – recommended by Lyman Dust Control Co (local to MT, used by Flathead County). Petroleum resin emulsion, diluted at rate of 1:4-1:7 (product:water). Residual buildup reduces dilution to 1:10. Application rate of diluted coherex is 0.5-1 gal/sq yd. Contains “no volatiles or cutback solvents.” The goal is to create a solid, dense, waterproof road base. Can either be mixed in with the base when constructing roads, or sprayed on the top where it penetrates the surface to a certain depth. Can be stored for long periods, even in winter.

Other

Test a mix of dead wood & vegetable oil – not very applicable to a roadway situation. It should be noted that a Soybean Oil byproduct (“soapstock” or “Soyl”) has been used in Minnesota for dust suppression.

Soybean Oil byproduct - The oil penetrates and bonds with the bedding material which forms a sort of shield for the surface. Environmentally friendly (see website). Not applicable for roads with continuous heavy trucks. More expensive than CaCl, but lasts an entire summer, with slight residual benefits each year. Extra application needed for potholes. **Supposed to last 1 year, but salesman says biodegradable in 1 month? Something doesn't make sense. A different manufacturer did not recommend using it for dust control on roads.**

DSA (Driving Surface Aggregate) – similar to a gravel lift, but made entirely with a well-graded mix of crushed rock (no sand or silt) so that it packs very densely. This way, dust is reduced. Requires maintenance, but less often than a typical gravel road. Reduction in sediment runoff, and no chemicals or binders required. Placed with a paver, then rolled to a compacted thickness of either 6” or 4.5”

More Information and Various Brand-Name Products

<http://www.cabq.gov/airquality/fugitivedustcontrol.html>

COHEREX[®]

Effective Dust Control



Dust Retardant and Soil Stabilizer

Everyone is familiar with the problem of dust. When carried in the air it can damage crops, cause respiratory illness, effect visibility, spread disease and speed up the natural forces of erosion. Unchecked, it can add to pollution and adversely affect our entire ecology.

Coherex[®] was developed as a result of years of extensive research and thorough field and laboratory testing. **Coherex[®]** stabilizes soil against wind erosion, thereby eliminating airborne dust and movement of sand along the ground.

The Cohesive Approach. Not only is **Coherex[®]** useful in the treatment of soils, but also of coal, ores and other matter in which dust is undesirable or where an over-all increase in particle size is desired.

Soil Stabilization. Cohesiveness imparted to soil without drastically altering its makeup.

Application Use:

- Roadway/Shoulder/Laneway Dust Control
- Orchard and Vineyard Dust Control
- Campsites
- Railroad Grades
- Slope Stabilization
- Ore Dust Control
- Vacant Fields



PRODUCERS of GOLDEN BEAR PRESERVATION PRODUCTS



Fast and easy spray application provides long lasting dust control

Coherex... solving your dust problems.

Coherex® is well suited where a controlled or regular application can be performed. Apply Coherex® by spraying the area with sufficient amount of the diluted dust-binder to penetrate the layer of dust to the depth required. When determining the ratio of Coherex® to water, the depth of penetration is controlled by the total amount of product applied (concentrate plus water) and that the thickness of the deposit of resins on the dust particles is controlled by the amount of Coherex® concentrate applied. The type of soil influences both the amount of product required to saturate it and the time required to reach the depth of penetration desired. Spreader trucks, hand sprayers, orchard sprayers, or other standard equipment can be used.

Coherex® ... effective soil control.

Coherex® dust retardant provides a clean and economical dust control. By coating the dust particles, Coherex® creates cohesive membranes that attach themselves to adjacent particles resulting in “agglomerates” too heavy to be dislodged by wind. Coherex® is well suited in applications where a controlled or regular application can be performed.

Used as a soil stabilizer in the base construction of road beds. Added to your compaction/dust control water, Coherex® will create a solid, dense, waterproof road base. A longer lasting road starts with better built road base.

Coherex® is a petroleum resin and water emulsion containing no volatiles or cutback solvents. It is composed of 60% semi-liquid natural petroleum resins and 40 % wetting solution. The resulting solution carries the resinous particles into the layer of dust to be treated. The emulsion can be stored for long periods and can be freeze stabilized for winter storage. While prolonged storage of diluted Coherex® might result in stratification, simple agitation or stirring will prepare the mixture for use.

Coherex® is an emulsified petroleum resin and is diluted with water for application. Application rate depends on the area of use and soil makeup. Typical starting dilutions of Coherex® with water are between 1:4 to 1:7 (product : water). With a buildup of residual over regular use, continued long-term treatments potentially can be reduced to 1:10 to 1:15 dilutions. Application rate of diluted Coherex® is generally ½ to 1 gallon per square yard (2-4 liters) per square meter). The build-up of Coherex® residual also means that areas can be graded and the build up of resin will remain in the soil.

The “agglomeration” effect gives depth to the dust retardant and not just a surface crust.

TRICOR REFINING, LLC
 Producers of GOLDEN BEAR PRESERVATION PRODUCTS
 P.O. Box 5877, Bakersfield, CA 93388-5877
 Phone 661.393.7110 ext. 107
 www.tricorrefining.com

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PRODUCTS: DUST CONTROL

[DUST CONTROL PRODUCTS OVERVIEW](#)[EARTHBIND™ 100](#)[EARTHBIND™ BP](#)[EARTHBIND™ WATER TRUCK](#)

Earthbind™ 100 Safety Information

With trends continuing towards strict health, safety and environmental regulations, Earthbind™ is an efficient and effective method to reduce dust-related environmental and health concerns. Plus, it aids in complying with clean air and water requirements by reducing airborne dust and preventing erosion.

Traditional dust control products are made of potentially carcinogenic petroleum oils and are diluted in highly volatile and flammable solvents. Others contain chemicals that are reported to be corrosive to metal, vehicles or other equipment that may come into contact with the treated areas. Some contain soluble anions that are harmful to aquatic organisms or become absorbed by plant roots. Once absorbed, anions are transported to leaves and twigs where they eventually accumulate to toxic levels. Anions can also raise the osmotic concentration of the soil, thereby diminishing the availability of water to plant roots and retarding metabolic functions, photosynthesis and growth.

Other dust control products are water-soluble. Rainfall can cause the product to wash-off into surface waters. When the product reaches these waterways, it reduces light penetration and can lead to the reduction of photosynthesis by phytoplankton, lowering the oxygen balance and interfering with aquatic life.

Earthbind™ is a safe, long-lasting and economical solution for base stabilization, dust and erosion control. The individual products that are used to create Earthbind™ are all classified as non-carcinogenic and have been tested to be safe for humans and the environment. Once applied and with adequate time to set-up, Earthbind™ is resistant to corrosion and does not re-emulsify when it rains.

When used properly, Earthbind™ is:

- Non-irritating to eyes
- Non-carcinogenic
- Non-flammable
- Non-corrosive to metal
- Non-hazardous waste
- Not harmful to aquatic and terrestrial life

Often there is a concern for fish since silt run-off from roads often ends up in nearby waterways. Earthbind™ proved to be of "low concern" in a fish toxicity test since, according to EPA standards, it was given a rating of LC50. A U.S. Fish and Wildlife Research Information Bulletin (#84-78) classifies LC50 values of 100 - 1000 mg/l as "practically non-toxic." Earthbind™ exhibits a low level of toxicity towards fish even at a very high concentration of product-higher than would ever be used in the field.

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EnviroKleen® and EK-35® Synthetic Organic Dust Control®

Tough on dust, easy on the environment

Runway or roadway, concert venue to construction site to unpaved open area, if the problem is fugitive dust or an unstable surface, the antidote is Midwest's EnviroKleen or EK-35. Like all Midwest products, these powerful synthetic organic fluids are reliably consistent and consistently reliable month to month, season to season, and year to year.

Created in Midwest's own laboratory, EnviroKleen and EK-35 were the first Synthetic Organic Dust Control® products on the market. Unique in the industry, both products have binder systems that capture fines and keep them locked into the surface, preventing dust from escaping. We formulated both products to be as gentle on the environment as they are tough on dust and unstable surfaces.

Vital statistics

- EPA-verified safe for people and the environment
- EPA-verified effective for reducing PM10 and PM2.5
- Certified non-corrosive by Boeing
- Creates pavement-like strength; enhanced by traffic
- Can be reworked without reapplication
- Does not evaporate or leach out of the surface
- Performs well at extreme temperatures
- Can be stored at temperatures down to -50° F
- Readily biodegradable in natural environments
- Works with all types of soils and aggregates

*EnviroKleen
and EK-35 are
ranked first in all
categories tested
by the U.S. Army
Corps of Engineers.*



Why EnviroKleen and EK-35?

Treating a symptom like dust is a temporary band-aid. Midwest goes after the *root cause* of a problem like surface instability and works tenaciously and without compromise until we find the optimal solution. In this case, the solution is the Synthetic Organic Dust Control and the binding technology we invented for use in the manufacture of EnviroKleen and EK-35.

EnviroKleen is formulated with a polymeric binder; EK-35 with a resin binder made from renewable resources. Both products are superior choices for industrial, construction, and municipal applications. They quickly penetrate dust and remain actively effective on clay, sand, gravel, limestone, and most native soils regardless of the weather or how severe the traffic. That is because their binder systems interlock and durably bind surface aggregate and fines together through both cohesive and adhesive

mechanisms. As fines are generated, they are captured, preventing them from escaping as dust. EnviroKleen and EK-35 are cost-effective for controlling PM10 and PM2.5 from open fugitive dust sources, and unlike other available products they will not track onto public roadways or stick to vehicles. Both products provide longer-lasting performance and require fewer applications than other dust control and surface-stabilization methods – regardless of season.

Managing fines with EnviroKleen and EK-35 can save tens of thousands of dollars annually during the lifecycle of a surface.



Conventional dust control methods can create greater problems than the dust itself – lingering environmental and health concerns, for example. Alternatives like water provide short-term solutions that involve labor-intensive, multiple applications. Road salts are sodium chloride, calcium chloride, potassium chloride,

Compare EnviroKleen and EK-35 to Other Dust Control Methods

Performance Benefits	EnviroKleen and EK-35 Synthetic Organic Fluids	Water	Road Salts ¹	Asphalt Emulsions	Petroleum Resins	Lignin
Longer lasting	●			●	●	
Year-round protection	●		●			
Passes EPA static sheen test	● ²	●	●			
Non-petroleum product	●	●	●			●
Colorless	● ²	●	●			
Not water-soluble/cannot be diluted	●					
No poly-nuclear aromatic hydrocarbons (PAH)	●	●				●
Will track	●		●			
Sprayable gallons required for a 1-mile x 30' wide road	1,800	550,000	8,825	18,480	13,200	5,280
Storm drain risk	Low	Low	High	High	High	High

¹Road salts are sodium chloride, calcium chloride, potassium chloride, magnesium chloride and ferrocyanide salts.

² EnviroKleen passes the EPA static sheen test and is colorless.

Easy to be green

With chemists in our lab and experts on our customers' worksites, Midwest has the home-grown ability to manufacture products that will not harm the environment and, in many instances, will help it. Our chemists think green from source materials to formulation and from production to application.

Special Delivery – The E-Sprayer™ System

The "E" in E-Sprayer System, an efficient product-dispensing solution, stands for EnviroKleen and EK-35, the products for which it was specifically designed. Portable, versatile and compact, the E-Sprayer can be mounted on any light-duty truck from an F-150 flatbed one-ton trailer to a military humvee. Powered by a 4.7-hp Diesel /JP8 fuel electric start engine and Gorman-Rupp pump, the E-Sprayer requires only one person to operate and facilitates universal application with an 8-foot spray bar. Flow is easily controlled with the throttle or motorized regulator.



Tested and verified – independently

Midwest believes in proving claims, rather than just making them, so our clients can be sure they are getting what they pay for from both performance and environmental perspectives.

- US EPA ETV* test data verifies that EnviroKleen and EK-35 are safe for people and the environment as well as effective in suppressing PM10 and PM2.5 levels. No other synthetic fluids have achieved this designation.
- EnviroKleen and EK-35 comply with requirements of the Clean Water Act and National Pollution Discharge Elimination System and realize fines preservation for surface stability and dust control.
- The synthetic organic fluid in each product meets the criteria for the term synthetic as established by the US EPA for sediment toxicity, biodegradability, PAH content, aquatic toxicity, and being oil-sheen free.
- The non-corrosive properties of EnviroKleen and EK-35 have been certified by Boeing Document D6-17487, the most stringent corrosion standard in the United States.

The protocols Midwest uses in testing its products under US EPA guidelines are 2 - 20 times more stringent than those used by our competitors. Proof of these verifications and certifications are available any time from Midwest. Before considering other dust-control solutions, remember to ask for such proof to protect yourself from false claims.

*U.S. Environmental Protection Agency's Environmental Technology Verification Program

Choice of the Military: EnviroKleen and EK35 in Action

Clear vision is a military necessity, but the conditions in which our forces operate fly in the face of that need. Dust, sand, and dirt obstruct vision and also attack and weaken critical vehicle and aircraft parts. The U.S. Military chooses EnviroKleen and EK-35, ranked first in all categories tested by the U.S. Army Corps of Engineers, to enhance safety and visibility for CH-46 Chinook and CH-53 Sea Stallion helicopter pilots.

Preserving Gravel Runways in Cold Regions

EnviroKleen and EK-35, the backbone of Midwest's Fines Preservation programs, are able to stabilize gravel runway surfaces, increase their strength, and preserve service life by keeping the fines bound to the surface. Applied in extreme temperatures, both products are applied neat and remain active and re-workable. The result? Fines preservation programs can achieve an 80% decrease in dust levels for up to four years and a decrease in runway lifecycle costs of 70%, or up to \$40,000 in annual savings. As many as two to five cubic meters of fines are saved at every take-off and landing on treated runways. Learn more about our gravel runway resources at www.gravelrunway.com.

If the shoe doesn't fit . . .

One size fits all does not always make for a good fit; unique problems require unique solutions. Midwest is a particle-control pioneer, not a me-too company. Our product development begins with a challenge and ends when we produce a solution that proves its worth in the field. Off-the-shelf is fine when it works, but when it does not, Midwest has the capability and tenacity to engineer a formula for your specific needs.

More reasons to choose Midwest

Midwest is the world leader in environmentally-sound, dust-control technology for every application where fugitive dust is a problem. We bring our customers more solutions, documentation and support than any other manufacturer. On a daily basis, we challenge ourselves to become even more accessible problem-solvers so we can set a new industry standard for proactive and responsive service. Pushing the envelope is part of our corporate DNA, and we strive, always, to develop cutting-edge processes, products and services; stay on top of the learning curve, and educate our customers for our mutual success.

EnviroKleen® Synthetic Organic Dust Control®

SECTION I — IDENTIFICATION OF SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

TRADE NAME:	EnviroKleen®
CHEMICAL NAME:	Synthetic Organic Dust Control®
SYNONYMS:	Isoalkane and Binder System
CHEMICAL FAMILY:	Dust Retardant and Stabilization Agent Formulated Isoalkane and Binder (Patents #7,081,270 and # 7,074,266)
CAS REGISTRY NO.:	Product a Blend - No Number Assigned

SECTION II — COMPOSITION/INFORMATION ON INGREDIENTS

NAME	CAS REG NO.	%
Severely hydrotreated, high viscosity synthetic iso-alkane	Non-hazardous	75 - 95%
Polyolefin	Non-hazardous	5 - 25%

SECTION III — HAZARDS IDENTIFICATION

Synthetic Iso-alkane	May be irritating to breathing passages upon excessive heating, otherwise this product is essentially non-hazardous. Mist 8 hour TLV-TWA = 5mg/m ³ (ACGIH)
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SECTION IV — FIRST AID MEASURES

EYES:	Flush eyes with flowing water at least 15 minutes, get medical attention. Do not use any eye ointment. Remove contact lenses.
INHALATION:	Move subject to fresh air. If victim is not breathing perform artificial respiration. Administer oxygen if available. Keep victim warm and at rest. Seek medical attention as soon as possible.
SKIN:	Flush with large amount of water or wash with soap and water. Seek medical attention if irritation persists.
INGESTION:	DO NOT induce vomiting because of aspiration into the lungs. EnviroKleen® has a laxative effect and will be eliminated quickly. Seek medical attention.
(NEVER GIVE FLUIDS OR INDUCE VOMITING IF PATIENT IS UNCONSCIOUS OR HAVING CONVULSIONS.)	
NOTE TO PHYSICIAN:	Monitor respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis or pneumonitis.

SECTION V — FIRE FIGHTING MEASURES

FLAMMABILITY:	Nonflammable, but will burn on prolonged exposure to flame or high temperature.
FLASH POINT (TEST METHOD):	>338°F (>170°C), open cup, ASTM D92, Cleveland
AUTOIGNITION TEMPERATURE:	664°F (351°C)
UNUSUAL FIRE AND EXPLOSION HAZARDS:	Do not cut, weld, heat or drill or pressurize empty container.
MATERIALS TO AVOID:	Low fire hazard. Must be moderately heated before ignition will occur. Avoid contact with strong oxidizing agents, including peroxides, chlorine and strong acids.
PRODUCTS OF COMBUSTION:	Carbon dioxide, carbon monoxide, smoke and irritating fumes as products of incomplete combustion.

SECTION V — FIRE FIGHTING MEASURES (continued)

EXTINGUISHING MEDIA AND INSTRUCTIONS:

If a tank, railcar or tank truck is involved in a fire isolate for 0.5 miles in all directions. Shut off fuel to fire if it is possible to do so without hazard. If this is impossible, withdraw from the area and let the fire burn itself out under controlled conditions. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire. Cool containing vessels with water spray in order to prevent pressure build-up, autoignition or explosion.

SMALL FIRE:	use dry chemicals, foam, CO ₂ .
LARGE FIRE:	use water spray, fog of foam. For small outdoor fires portable extinguishers may be used and SCBA (self-contained breathing apparatus) may not be required. For all indoor fires and any significant outdoor fires SCBA if required. Respiratory and eye protection are required for fire fighting personnel.

SECTION VI - ACCIDENTAL RELEASE MEASURES

SPILL AND LEAK PROCEDURES:	ELIMINATE ALL IGNITION SOURCES. Stop leak without risk and contain spill. Absorb with inert absorbent materials such as clay or sand. Place absorbent in closed metal containers for later disposal or burn in appropriate facility. Keep spills out of sewers and open bodies of water
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SECTION VII — HANDLING AND STORAGE

STORAGE:	Keep in a cool, dry, ventilated storage area and in closed containers. Keep away from sources of ignition and oxidizing materials.
HANDLING:	KEEP AWAY FROM SOURCES OF IGNITION. Do not reuse empty containers. Practice good hygiene. Wash hands before eating. Launder clothes before reuse. Discard saturated leather goods.

SECTION VIII — EXPOSURE CONTROL/PERSONAL PROTECTION

RESPIRATORY PROTECTION:	None required if good ventilation is maintained. If mist is generated by heating or spraying use a NIOSH-approved organic respirator with a mist filter.
VENTILATION:	Under normal handling conditions special ventilation is not necessary. If operation generates mist or fumes use ventilation of keep exposure to airborne contaminants below exposure limits. Chemical splash, goggles recommended.
EYE PROTECTION:	Clothing to minimize skin contact, long sleeves, boots or shoes. For casual contact PVC gloves are suitable, for prolonged contact use neoprene or nitrile gloves.
PROTECTIVE CLOTHING:	

SECTION IX — PHYSICAL AND CHEMICAL PROPERTIES

BOILING/MELTING POINT @ 760 mm Hg:	>600°F (>316°C)
VAPOR PRESSURE mm Hg @ 20°C:	negligible at ambient temperature
SPECIFIC GRAVITY OR BULK DENSITY:	0.83
SOLUBILITY IN WATER:	insoluble in water
APPEARANCE:	viscous, clear liquid
ODOR:	none
POUR POINT:	-33°F (-36°C)
VISCOSITY (Brookfield):	35 – 50cps @ 20°C 100 – 140cps @ 0°C 145 – 175cps @ -5°C
pH:	N/A, not an aqueous solution or emulsion

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Canton, Ohio 44711
www.midwestind.com

Tel 330.456.3121
Fax 330.456.3247
Emergency Phone Number 1.800.321.0699

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SECTION IX — PHYSICAL AND CHEMICAL PROPERTIES - continued

ACIDITY: none
ALKALINITY: none

SECTION X — STABILITY AND REACTIVITY

STABILITY: Stable under normal handling conditions.
 Stable stored at temperatures between -40°F and + 180°F.
 Can react with strong organic oxidizing materials.

**CHEMICAL INCOMPATIBILITY:
 HAZARDOUS DECOMPOSITION
 PRODUCTS:** Thermal decomposition in the presence of air may yield carbon monoxide and/or carbon dioxide, smoke, hydrocarbons and irritating fumes.

**HAZARDOUS POLYMERIZATION:
 CONDITIONS TO AVOID:
 CORROSIVE TO METAL:** Does not occur under normal industrial conditions.
 Excessive heat and flame.
 No

SECTION XI — TOXICOLOGICAL INFORMATION

EFFECTS OF OVEREXPOSURE:

ACUTE:

INHALATION: Inhalation is highly unlikely. However prolonged or repeated inhalation of fumes or mists may cause irritation to the respiratory tract. Product deposits in lungs may lead to fibrosis and reduced pulmonary function.

SKIN: It is not a skin irritant. However prolonged or repeated contact may cause skin irritation, dermatitis or oil acne.

EYES: Prolonged or repeated contact may be irritating to eyes. Will not cause permanent damage.

INGESTION: Relatively non toxic to digestive tract.

MUTAGENIC: Mutagenic activity test are negative toward: Salmonella Typhimurium, Salmonella-Escherichia coli and Chinese Hamster ovary.

REPRODUCTIVE TOXICITY: Based on data to date it does not pose a reproductive risk.

CARCINOGENICITY:

Based on studies to date EnviroKleen® is not known to be carcinogenic to humans.

- ACGIH (mists) - Based on available human studies, exposure to product mist alone has not demonstrated to cause human effects at levels below 5 mg/m3.
- IARC - IARC group 3; cannot be classified as to carcinogenicity to humans.
- NTP - No studies were found.
- IRIS - No studies were found.
- OSHA - OSHA PEL (8 hour TWA) = 5 mg/m3 for synthetic product mists.

SECTION XII — ECOLOGICAL INFORMATION - EnviroKleen® Aqautic Toxicity Results

- Methods for Measuring the Acute Toxicity of Effluents and Receiving Water to Freshwater and Marine Organisms, EPA/600/4-90/027F.
- Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, EPA/600/4-91/002.
- Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms, EPA/600/4-91/003.

	Ceriodaphnia dubia	Fathead minnow	Americamysis bahia	Rainbow Trout
ACUTE/SURVIVAL (mg/L)				
LC50	>1000	>1000	>1000	>1000
NOEC	1000	1000	1000	1000
LOEC	>1000	>1000	>1000	>1000
CHRONIC/SURVIVAL (mg/L)				
LC50	>1000	>1000	>1000	>1000
NOEC	1000	1000	1000	1000
LOEC	>1000	>1000	>1000	>1000
CHRONIC/GROWTH/ REPRODUCTION (mg/L)				
LC50	>1000	>1000	>1000	>1000
NOEC	1000	1000	1000	1000
LOEC	>1000	>1000	>1000	>1000

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See attached test results:

1. ABC Laboratories, Inc. Americamysis bahia, Fathead minnow, Ceriodaphnia dubia.
2. ABC Laboratories, Inc. Rainbow trout

LC50 -Lethal Concentration, 50%
 NOEC - No Observable Effects Concentration
 LOEC - Lowest Observable Effects Concentration

The LC50 level is the lethal concentration of the chemical under test that kills 50% of the test organisms in the specified amount of time.

Comparison of the EPA guidelines to the LC50 levels of all species show that EnviroKleen® is practically non-toxic to all species. When used and applied properly EnviroKleen® is not known to pose any ecological problems.

SECTION XIII — DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD: Consult your local authorities for regulations. Preferred waste management: recycle or reuse, incinerate with energy recovery, disposal in a licensed facility. Disposal facility should be compliant with state, local and federal government regulations.

SECTION XIV — TRANSPORTATION INFORMATION

D.O.T. PROPER SHIPPING

NAME (49CFR172.101): None

HAZARDOUS SUBSTANCE (40CFR116): N/A

REPORTABLE QUANTITY (RQ): N/A

D.O.T. HAZARD CLASSIFICATION (49CFR172.101): Non-regulated

D.O.T. PLACARDS REQUIRED: None

POISON CONSTITUENT (49CFR173.343): N/A

BILL OF LADING DESCRIPTION: Dust control agent

C NO.: N/A

UN/NA CODE: N/A

SECTION XV— REGULATORY INFORMATION

EPA SARA TITLE III hazard class: None

OSHA HCS hazard class: Non-OSHA hazardous (29CFR1910.1200)

EPA SARA Title III Section 313 (40CFR372) Toxic Chemicals present in quantities greater than the “de minimus” level are:

None

TSCA: Components of this product are listed on TSCA inventory
 This product is not a “controlled product” under the Canadian Workplace Hazardous Material Information System.

Canadian WHIMIS: All components of this product are listed on Domestic Substance List.

Canadian DSL: All components of this product are listed on Domestic Substance List.

California Proposition 65: Does not contain any Prop 65 chemicals.

SECTION XVI — OTHER INFORMATION

ABBREVIATIONS AND SYMBOLS: N.D. - Not Determined
 N.A. - Not Applicable
 N.T. - Not Tested
 < - Less Than
 > - Greater Than





35585 Curtis Boulevard • Eastlake, Ohio 44095 • (440) 951-8633 • (440) 951-4341 FAX

EnviroLogic[®] 500

Dust Control Oil Concentrate

Description

Dust and its undesirable results are apparent to everyone. Most dust control methods are either unsuitable for the environment or are ineffective. EnviroLogic[®] 500 is a biodegradable and non-toxic dust suppressant that works. The specialty performance additives safely coat dust particles and prevent them from becoming airborne. The natural ester technology allows biodegradation keeping waterways and greens clean.

Typical Properties

Kinematic Viscosity, cSt @ 40°C	ASTM D 445	35
Specific Gravity @ 25°C	ASTM D 1122	0.92
Color	Visual	Golden
Water Solubility emulsion	10% vol. in water	White



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EnviroLogic[®] 500

Dust Control Oil Concentrate

Comparison of Commercially Available Materials

Classic dust control products have been everything from salt solutions to crushed leather in oil. The following table simplifies the comparison of commercially available dust control products.

Product Type	Advantage	Disadvantage
Waste Oil	Inexpensive	Carcinogenic
Hydrocarbon Emulsions	Moderate/High Price	Hazardous/Low Biodegradability Variable Emulsion Stability
Hydrocarbon Bottoms Point	Inexpensive	Carcinogenic/Low Flash
Brine	Inexpensive	Short Effective Life/Hygroscopic
Calcium/Sodium Salt Solutions	Moderate price	Limited Useful Life Hygroscopic Harmful to Water Table
EnviroLogic [®] 500	Moderate price Forms Stable Emulsions Biodegradable Harmless to Water Table Extended Useful Life	None





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EnviroLogic[®] 500

Dust Control Oil Concentrate

Equation for Calculating Dust Control Coverage (Volume)

- $\text{Area (ft}^2\text{)} \times 144 \text{ in}^2/\text{ft}^2 = \text{Area (in}^2\text{)}$

- For a 1/32 inch layer of dust control concentrate:

$$\text{Area (in}^2\text{)} \times 0.03125 \text{ in} = \text{Volume (in}^3\text{)}$$

- To convert from cubic inches (in³) to gallons:

$$\text{Volume (in}^3\text{)} / 231 \text{ in}^3/\text{gallon} = \text{Volume (gallons)}$$

- Application recommendation: 4 to 1 ratio (/ # of drums by 4)

- In drums:

$$\text{Volume (gallons)} \times 1 \text{ drum}/55 \text{ gallons} = \text{Volume (drums)}$$

Lignin Sulfonate -Know the Facts !

Much is known about the use of Lignosulfonates (also called lignin sulfonate and sulfite lignins) and its application on unimproved road surfaces as a soil stabilization and dust control agent. It has never been responsibly suggested that the use of lignin would have any negative impacts on our environment and/or human health. This document will discuss lignin from a factual, practical and scientific basis. Lignin contains no constituents that are considered hazardous by any Government agency. Further, its health rating is 0, which simply means exposure offers little or no risk to either plants or humans. Further, the constant referral by the opponents to its use as a soil stabilization and dust control agent on the roads of Storm Mountain as an "oil slick" or as creating something like an "oil slick" is scientifically impossible. Lignin simply contains no oil based contaminants. Like magnesium chloride it is soluble in water. Further, lignin is biodegradable.

What is Lignin Sulfonate

Commercial lignin is produced as a co-product of the paper industry. It is separated from trees by a chemical pulping process. Lignins are products of sulfite pulping. Kraft lignins (also called sulfate lignins) are obtained from the kraft pulping process. Other delignification technologies use an organic solvent or a high pressure steam treatment to remove lignins from plants. Because lignins are very complex natural polymers with many random couplings, the exact chemical structure is not known. Physical and chemical properties differ depending on the extraction technology. For example, while lignins are **hydrophilic** (will dissolve in water), kraft lignins are **hydrophobic** (will not dissolve in water). The usefulness of commercial lignin products comes from their dispersing, binding, complexing and emulsifying properties. Industry first began to use lignins in the 1880s when lignin sulfonates were used in leather tanning and dye baths. Since then, they have even found applications in food products, serving as emulsifiers in animal feed and as raw material in the production of vanillin (widely used as an ingredient in food flavors, in pharmaceuticals and as a fragrance in perfumes and odor-masking products). Lignin uses have expanded into literally hundreds of applications - impacting on many facets of our daily lives.

For the purposes of this document we are concerned with lignin's use as a very effective and economical adhesive, acting as a binding agent or "glue" in pellets or compressed materials. Lignosulfonates are used on unpaved roads to reduce environmental concerns from airborne dust particles and to stabilize the road surface. These binding properties also make the product a useful component of the making of charcoal briquettes, ceramics, linoleum paste, and plywood and particle boards to name a few.

Lignins have a long history of use on roads as a method for dust control and surface stabilization. Lignin road products are derived from the lignin that naturally binds cellulose fibers together to give trees and plants firmness. These products are a safe and economical alternative to petroleum and salt-based products that are also sometimes applied to road surfaces.

The original method of applying Lignins to road surfaces for dust control was very simple: dilute raw Lignin solutions were sprayed in light applications onto dirt roads. Over time, road surfaces began to show an

improved stabilization, increasing the appeal of using Lignins. Lignin is well suited for a variety of uses such as parking lots, driveways, and road shoulders, where pavement is too costly and dust conditions become intolerable. The properties of raw lignin are enhanced when used, in combination with other stabilizers such as magnesium chloride. This is because lignins have a natural adhesive property when moist. When applied to dirt roads, the Lignin solution coats individual road particles with a thin adhesive-like film that binds the particles

together, while the magnesium chloride attracts the water molecules which also helps to bind the individual road particles together. The lignin further acts as a dispersant, allowing the particles to pack closer together for a stronger surface. Consequently, water uptake by the road bed surface is greatly reduced and the binder is less likely to be washed away by rain.

Benefits of Lignins for Road Applications

Creates a Denser, Firmer Road Cap - Lignin treatment eliminates the sliding hazards of loose dirt and gravel by binding them into a hard, skid-resistant surface.

Safe for the Environment - Lignins are non-toxic when properly applied, making them safe for foliage and surface water surrounding roadways. Lignins are not corrosive and can be applied without special equipment or clothing.

Improves Safety - By controlling dust clouds, visibility on dirt roads is significantly increased, adding to driving comfort and safety.

Reduces Road Repairs - Hardened road surfaces are less likely to suffer the ribbed "washboard" effect common with untreated gravel or dirt roads. As a result, frequent grading can be reduced or eliminated.

Commercial Lignin products meet the specifications of the U.S. Forest Service Administration, General Service Administration and local and regional government standards. Lignin use on roads has been endorsed by various agencies for decades.

In the development of this document, studies conducted by the following agencies were consulted:

1. The Lignin Institute, a non-profit trade association of manufacturers and suppliers of lignin products.

Approved Products List

The Dirt & Gravel Road Maintenance Program was founded on solid environmental principles. One of these principles is the program's strict limitations on the use of products that may cause damage to the environment in any way. Listed here are the products approved for purchase and use with program funding. The program does not endorse these or any other individual products.

PETROLEUM EMULSION DUST SUPPRESSANT			
PRODUCT NAME	DISTRIBUTOR	TYPE	APPROVED APPLICATION RATE
Penn Suppress "D"	Colin Kible American Refining Grp Route 36, Pleasantville, PA 16341 (814) 589-5180	Petroleum Emulsion	1:4 emulsion to water or more dilute
Ultrabond 2000	Michael George JMG Enterprises, Inc. 10027 Rt 403 Hwy South Seward, PA 15954 Phone:(814) 446-5625 Toll Free:(800) 446-6785 Fax: (814) 446-5627	Petroleum Emulsion	1:4 emulsion to water or more dilute
Coherex	Dave Scott D&D Emulsions, Inc. 270 Park Ave East, Mansfield, OH 44902 Phone: (419) 522-9440 Fax: (419) 522-8606	Petroleum Emulsion	1:10 emulsion to water or more dilute
Dust Bond	Dave Scott D&D Emulsions, Inc. 270 Park Ave East, Mansfield, OH 44902 Phone: (419) 522-9440 Fax: (419) 522-8606	Petroleum Emulsion	1:10 emulsion to water or more dilute A variant of Coherex

SYNTHETIC FLUID DUST SUPPRESSANT			
PRODUCT NAME	DISTRIBUTOR	TYPE	APPROVED APPLICATION RATE
EK 35	Dan Carpenter Midwest Ind. Supply PO Box 8431 Canton, OH 44711 Phone: (800) 321-0699 Fax: (330) 456-3247 www.midwestind.com	Synthetic Fluid	100% active, no water required for application
EnviroKleen	Dan Carpenter Midwest Ind. Supply PO Box 8431 Canton, OH 44711 Phone: (800) 321-0699 Fax: (330) 456-3247 www.midwestind.com	Synthetic Fluid	100% active, no water required for application

ACRYLIC POLYMER DUST SUPPRESSANT			
PRODUCT NAME	DISTRIBUTOR	TYPE	APPROVED APPLICATION RATE
Pave-Cyrl Suppress	Chuck Geyen Rohm & Haas Company (585) 424-5161 cgeyen@rohmmaas.com	PVA	As-received [51% solids]
Pave-Cryl Suppress Plus	Chuck Geyen Rohm & Haas (585) 424-5161 cgeyen@rohmmaas.com	PVA	As-received [51% solids]
DirtGlue	Bernhard Mueggler DirtGlue Enterprises PO Box 1647 Wakefield, MA 01880 Phone: (888)606-6108 Fax: (508)861-0550	PVA	As-received [>50% solids]

ROAD FILL MATERIALS			
PRODUCT NAME	DISTRIBUTOR	TYPE	APPROVED APPLICATION RATE
Recmix of PA, Inc.	Daniel Mueller Recmix of PA, Inc. 359 North Pike Road Sarver, PA 16055 www.recmixusa.com Phone: (724)353-0055	Recycled Steel Slag	Road Fill Material
Process Recovery Corporation	Scott A. Brown Process Recovery Corp. 2909 Windmill Road Sinking Springs, PA 16808 Phone: (610)670-8500 Fax: (610)670-8508	Recycled Foundry Sand	Road Fill Material

ROAD FILL MATERIALS			
PRODUCT NAME	DISTRIBUTOR	TYPE	APPROVED APPLICATION RATE
Envirolime	James V. Derby Carmeuse North America Technology Center 3600 Neville Road Pittsburgh, PA 15225 Phone: (717) 787-8821 Fax: (717) 705-3778	Ag-Lime Substitute	

Road Oyl[®]

Resin Modified Emulsion



Versatile and multi-purpose for dust control, erosion control and stabilization

Road Oyl is a resin modified emulsion that provides a cold applied high performance treatment for bare earth areas, stockpiles and for unpaved road surfaces. Formulated from tree resin ingredients, this state-of-the-art, non-ionic emulsion technology is unique in its high bonding strength and is appropriate for use even in close proximity to wetland areas and other areas of environmental sensitivity. Road Oyl provides the clean, high performance technology needed for any type of project.

Originally developed to solve severe dust problems on mine haul roads, Road Oyl has been used around the world for over 15 years.

Since Road Oyl is made from all natural ingredients harvested on a sustainable basis, it has never had a problem being approved for use in any application or as part of an environmental permit issued to an operating entity such as a landfill, steel mill or mine.

Road Oyl is versatile and multi-purpose in use for dust control, erosion control, stabilization, shoulder treatments and other specialized applications. It has been specifically designed and proven to be a long-term solution for efficient control of road dust as well as for use on mine tailings and stockpiles. Whether you are creating a landing strip, access road, haul road, hardened surface, trail or have erosion control requirements, Road Oyl provides a reliable, environmentally friendly binder.

Traffic on a Road Oyl surface will compact the surface into a smooth dust free pavement-like surface. It penetrates road aggregate and binds it into a surface proven stronger than asphalt. Road Oyl darkens the aggregate or soil that it's applied to slightly but maintains the same basic look, which makes it desirable in natural settings. Road Oyl will not track when applied as directed.

What is Road Oyl?

Road Oyl is a natural flexible pavement binder emulsion formulated from pine rosin and pitch in water. The pitch and rosin, which comprise roughly 50% of Road Oyl by weight, are co-produced with other timber products from southern pine in the southeastern United States. Pine pitch is a black, viscous "tar" derived from the distillation of wood; before the development of coal tar pitch. Pine rosin is the residue from distillation of turpentine oil from raw turpentine. The Road Oyl liquid is brownish in color with mild odor. When rubbed between the fingers, it becomes extremely sticky as the water evaporates.

Environmentally Friendly

Made from all natural products harvested on a sustainable basis, Road Oyl is non-hazardous and safe for the environment.

Economical

Road Oyl is shipped efficiently as a high concentrate and diluted with water before application. With its long lasting nature, you spend less time reapplying, saving you both time and money.

Long Lasting

The condition of the road, the degree of Road Oyl penetration, and the amount of traffic combine to determine the life of a Road Oyl application. It also helps stabilize the road in winter by protecting the road from water intrusion.

Physical Properties

Specific Gravity:	0.9 – 1.1 Kg/L
Weight per Gallon (US)	7.497 – 9.163 #/gallon
Appearance:	Light brown colored liquid emulsion
Odor:	Musty, woody
pH:	6 - 9
Boiling Point:	212°F (100°C)
Solubility in Water:	Dilutable
OSHA Hazard:	No
Flammability:	Non-flammable, non-combustible
Stability:	Stable under normal handling conditions
Corrosiveness:	Similar to water
Incompatibilities:	Can react with strong organic oxidizing materials, strong acids and strong bases.

Road Oyl is versatile and multi-purpose in use for dust control, erosion control, stabilization, shoulder treatments and other specialized applications.

Road Oyl®

SECTION I — IDENTIFICATION OF SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

TRADE NAME:	Road Oyl
CHEMICAL NAME:	Specialized Dust Suppressant and Soil Stabilization Agent
SYNONYMS:	Dust Retardant
CHEMICAL FAMILY:	N/A
MOLECULAR WEIGHT:	N/A
FORMULA:	N/A
CAS REGISTRY NO.:	Product a Blend - No Number Assigned

SECTION II — COMPOSITION/INFORMATION ON INGREDIENTS

NAME	CAS REG NO.	WT. %
Proprietary pitch/rosin blend	8016-81-7	40 – 60
	8050-09-7	
	8052-10-6	

SECTION III — HAZARDS IDENTIFICATION

Eye and skin irritant.

SECTION IV — FIRST AID MEASURES

EYES:	Flush eyes with flowing water for at least 15 minutes, get medical attention. Remove contact lenses.
INHALATION:	Move subject to fresh air. If victim is not breathing perform artificial respiration. Administer oxygen if available. Keep victim warm and at rest. Seek medical attention as soon as possible if breathing difficulty persists.
SKIN:	Flush with large amount of water or wash with soap and water. Seek medical attention if irritation persists.
INGESTION:	DO NOT induce vomiting because of aspiration into the lungs. Seek medical attention if irritation persists.
NEVER GIVE FLUIDS OR INDUCE VOMITING IF PATIENT IS UNCONSCIOUS OR HAVING CONVULSIONS.	
NOTE TO PHYSICIAN:	Monitor respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis or pneumonitis.

SECTION V — FIRE FIGHTING MEASURES

FLAMMABILITY:	Nonflammable, but will burn on prolonged exposure to flame or high temperature.
FLASH POINT (TEST METHOD):	>200°F (>94°C), aqueous blend
AUTOIGNITION TEMPERATURE:	Not determined
UNUSUAL FIRE AND EXPLOSION HAZARDS:	Do not cut, weld, heat or drill or pressurize empty container.
MATERIALS TO AVOID:	Avoid contact with strong oxidizing agents, including peroxides, chlorine and strong acids.
PRODUCTS OF COMBUSTION:	Carbon dioxide, carbon monoxide, smoke and irritating fumes.

SECTION V — FIRE FIGHTING MEASURES - continued**EXTINGUISHING MEDIA AND INSTRUCTIONS:**

If a tank, railcar or tank truck is involved in a fire isolate for 0.5 miles in all directions. Shut off fuel to fire if it is possible to do so without hazard. If this is impossible, withdraw from the area and let the fire burn itself out under controlled conditions. Withdraw immediately in case of rising sound from venting safety device or any discoloration of the tank due to fire. Cool containing vessels with water spray in order to prevent pressure build-up, autoignition or explosion.

**SMALL FIRE:
LARGE FIRE:**

use dry chemicals, foam, CO₂.
use water spray, fog of foam. For small outdoor fires portable extinguishers may be used and SCBA (self contained breathing apparatus) may not be required. For all indoor fires and any significant outdoor fires SCBA if required. Respiratory and eye protection are required for fire fighting personnel.

SECTION VI - ACCIDENTAL RELEASE MEASURES**SPILL AND LEAK PROCEDURES:**

ELIMINATE ALL IGNITION SOURCES. Stop leak without risk and contain spill. Absorb with inert absorbent materials such as clay or sand. Place absorbent in closed metal containers for later disposal or burn in appropriate facility. Keep spills out of sewers and open bodies of water.

SECTION VII — HANDLING AND STORAGE**STORAGE:**

Keep in a cool, dry, ventilated storage area and in closed containers. Keep away from sources of ignition and oxidizing materials. DO NOT FREEZE.

HANDLING:

KEEP AWAY FROM SOURCES OF IGNITION. Do not reuse empty containers. Practice good hygiene. Wash hands before eating. Launder clothes before reuse. Discard saturated leather goods.

SECTION VIII — EXPOSURE CONTROL/PERSONAL PROTECTION**RESPIRATORY PROTECTION:**

None required if good ventilation is maintained. If mist is generated by heating or spraying use a NIOSH approved organic respirator with a mist filter.

VENTILATION:

Under normal handling conditions special ventilation is not necessary. If operation generates mist or fumes use ventilation of keep exposure to airborne contaminants below exposure limits.

EYE PROTECTION:

Chemical splash, goggles recommended.

PROTECTIVE CLOTHING:

Clothing to minimize skin contact, long sleeves, boots or shoes. For casual contact PVC gloves are suitable, for prolonged contact use neoprene or nitrile gloves.

SECTION IX — PHYSICAL AND CHEMICAL PROPERTIES

BOILING/MELTING POINT @ 760 mm Hg:	212°F (100°C)
VAPOR PRESSURE mm Hg @ 20°C:	N/D
SPECIFIC GRAVITY OR BULK DENSITY:	0.9 – 1.1
SOLUBILITY IN WATER:	dilutable
APPEARANCE:	light brown colored liquid emulsion
ODOR:	musty, woody
pH:	6 – 9

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Fax 330.456.3247
Emergency Phone Number 1.800.321.0699

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SECTION X — STABILITY AND REACTIVITY

STABILITY:	Stable under normal handling conditions.
CHEMICAL INCOMPATIBILITY:	Can react with strong organic oxidizing materials, strong acids and strong bases.
HAZARDOUS DECOMPOSITION PRODUCTS:	Thermal decomposition in the presence of air may yield carbon monoxide and/or carbon dioxide, smoke, hydrocarbons and irritating fumes of sulfide oxides.
HAZARDOUS POLYMERIZATION:	Does not occur under normal industrial conditions.
CONDITIONS TO AVOID:	Excessive heat and flame.
CORROSIVE TO METAL:	Similar to water.

SECTION XI — TOXICOLOGICAL INFORMATION

EFFECTS OF OVEREXPOSURE

INHALATION:	Inhalation is highly unlikely. However prolonged or repeated inhalation of fumes or mists may cause irritation to the respiratory tract. Product deposits in lungs may lead to fibrosis and reduced pulmonary function.
SKIN:	Prolonged or repeated contact may cause skin irritation, dermatitis or oil acne.
EYES:	Prolonged or repeated contact may be irritating to eyes. Will not cause permanent damage.
INGESTION:	Relatively non toxic to digestive tract.

SECTION XII — ECOLOGICAL INFORMATION

When used and applied properly ROAD OYL is not known to pose any ecological problems.

SECTION XIII — DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD:	Consult your local authorities for regulations. Preferred waste management: recycle or reuse, incinerate with energy recovery, disposal in a licensed facility. Disposal facility should be compliant with state, local and federal government regulations.
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SECTION XIV — TRANSPORTATION INFORMATION

D.O.T. PROPER SHIPPING NAME (49CFR172.101):	Dust Control Agent
D.O.T. HAZARD CLASSIFICATION (49CFR172.101):	Non-regulated
D.O.T. PLACARDS REQUIRED:	None
BILL OF LADING DESCRIPTION:	Dust suppressant

SECTION XV — REGULATORY INFORMATION

EPA SARA Title III hazard class:	None
OSHA HCS hazard class:	Irritant
CERCLA (40 CFR 302.4):	None
TSCA:	Components of this product are listed on TSCA inventory.
Canadian WHMIS classification:	D2B, irritant
Canadian DSL:	All components of this product are listed on DSL (Domestic Substance List).
California Proposition 65:	Does not contain any Prop 65 chemicals.

SECTION XVI — OTHER INFORMATION

ABBREVIATIONS AND SYMBOLS:	N.D. - Not Determined
	N.A. - Not Applicable
	N.T. - Not Tested
	< - Less Than
	> - Greater Than

Soil-Sement®

Dust Control,
Erosion Control,
Stabilization





Outstanding Features and Benefits of Soil-Sement®:

- Nearly eliminates particulate matter (PM10 and PM2.5).
- Does not contain any detectable polycyclic organic matter (POM) which includes polynuclear aromatic hydrocarbons (PAH).
- Is environmentally safe, non-toxic, non-corrosive, non-flammable and does not pollute groundwater.
- Has a cumulative effect and creates a stabilized surface which will resist shifting, breaking up or sink failures.
- Offers maximum weatherability to wind, rain, ultraviolet light and other weather conditions.
- Increases load-bearing strength of all types of soils and surfaces.
- Prevents water from seeping into and destabilizing the surface.
- Dries clear, providing an aesthetically pleasing appearance.
- Meets air, water, groundwater and stormwater compliance.



What is Soil-Sement®

Dust and Erosion Control Agent

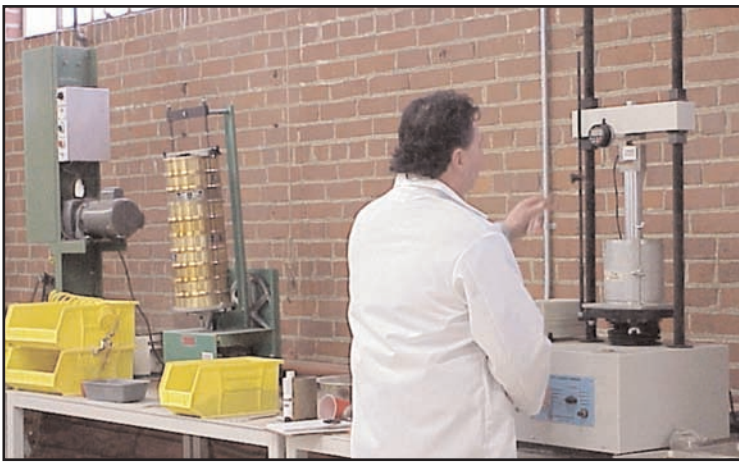
Soil-Sement® is an environmentally safe, advanced powerful polymer emulsion that produces highly effective dust control, erosion control and soil stabilization. Soil-Sement® provides excellent bonding, cohesion, versatility, cost-effectiveness, environmental compliance and superior overall performance.

Soil-Sement®'s effectiveness results from the length and strength of its unique polymer molecule formulation and those polymer molecules' ability to bond with the surface materials. Its chemical structure is made of molecules attached in relatively straight-linked chains and then cross-linked among other chains or grids that may be 1,000,000 molecules long. It is a true giant compared to the much smaller molecular structure of oil, calcium, petroleum resin and asphalt emulsion products, which range from 100 to 10,000 molecules. As a result, Soil-Sement® can be as strong as steel or as resilient as rubber.

Soil-Sement® is the cumulation of 24 years of focused research and development, and unparalleled concentration on PM10, PM2.5, erosion control and stabilization solutions. It yields proprietary one-of-a-kind polymer chemistry manufactured to rigid quality standards utilized in combination with field experience in all industrial, commercial and municipal environments. The result is a performance and value combination that is unequalled by other chemical and polymer products. As a result Soil-Sement® has been the standard of comparison for all chemical types, including polymer products, since it's introduction in 1978. Especially today Soil-Sement® exemplifies the fact that **all polymers are not made equal.**

A Soil-Sement® treated surface will provide you with optimum performance 365 days a year!





Since 1975, Midwest Industrial Supply, Inc. has built a reputation of leadership through products and services that continually redefine dust control, erosion control and stabilization technology.

Our customers expect products that deliver real benefits, with performance far superior to other types of products being used today.

Our advantages include a full on-site laboratory with the latest state-of-the-art equipment.

We also have a group of dedicated, experienced professionals who are always ready to assist you with all of your dust control, erosion control and stabilization needs.

Manufacturing Capabilities

We operate over 160,000 square feet of manufacturing and warehouse facilities in our Canton, Ohio location, with satellite operations located across the United States, Canada and Europe. We provide a complete research and development lab giving us total control over the formulation, manufacturing, quality and distribution of all of our products. Midwest's quality manufacturing process is designed to meet the criteria of ISO-9001.

Complete Customized Selling

We work with each customer to develop a customized dust or erosion control program that addresses your specific needs and requirements. Complete location surveys, soil evaluations, review of state and local air quality regulations, and other critical data are all combined as part of our detailed proposals and control plans. This determines the products, services, equipment, personnel, application schedules and budgets needed to do the job right.

Turn-key Applications

We offer complete turn-key application services. We serve our customers with a full-time fleet of properly equipped spray trucks and operators who are highly trained and professionally qualified. We provide field application services 24 hours a day, 7 days a week. Our central dispatch center maintains constant communications with the field operators for prompt routine service and immediate response to any emergency situation.

Recordkeeping and Reporting

We collect site, product, and application specific data in the field and create required daily reports which form the basis for the comprehensive, self-monitoring program needed for air quality compliance. Our administrative staff compiles required records of your dust and erosion control program and issues detailed quarterly and annual reports. These reports are prepared for presentation to state regulatory agencies for compliance with Title V certification provisions of the Clean Air Act and each state's air quality regulations.



CALCERT

INNOVATION ASSURED

“Soil-Sement® as a dust suppressant, in accordance with the manufacturer's instructions, will result in a significant reduction of PM₁₀...””

Now and In the Future... Leader in Environmental Stewardship Midwest Industrial Supply, Inc.

Midwest Industrial Supply, Inc. has over 28 years of experience of dust suppressant formulation, manufacturing and application experience. Our extensive research and development has resulted in products that are on the cutting edge of performance and environmental technology.

Midwest has always taken a leadership role in establishing regulatory requirements for chemical dust suppressants and stabilizers. We pride ourselves on the fact that our product line is engineered to reduce exposure to substances that cause cancer and other serious health effects...PM₁₀, PM_{2.5}, naturally-occurring

asbestos-laden soil, radiation, PAHs, POMs, lead, ozone depletion and global warming. In other instances our products can be utilized to reduce the health hazards of heavy metals in mining and tailing operations, pesticide containment in soils and volatile organic compound (VOC) containment in soils.



Through the years Midwest Industrial Supply, Inc. has voluntarily sought and received third party verification of its stewardship...CalCert, California Air Resources Board (CARB), USEPA ETV, Canadian ETV and numerous testing and research projects — just a few of which are mentioned in the pages of this brochure.

***MIDWEST...MAKING THE FUTURE
SAFER AND HEALTHIER FOR EVERYONE!***

Independent Tests & Certifications Confirm Soil-Sement®'s Superior Performance & Reliability!



CALCERT
INNOVATION ASSURED



Arizona Department of
Emergency & Military
Affairs (ADEMA)



The world's leading advocates of new environmental technologies, and internationally recognized scientific and engineering evaluators of environmental performance have verified that Soil-Sement® is highly effective for controlling dust and the damaging effects of erosion and sediment pollution, while protecting the environmental ecosystem.

The staff of the internationally renowned California Air Resources Board (CARB) conducted an independent verification of the air quality benefits of Soil-Sement®. In particular, the staff of CARB determined that the use of Soil-Sement® as a



dust suppressant, in accordance with the manufacturer's instructions, will result in a significant reduction of PM₁₀ emissions from unpaved roads without contributing to existing levels of volatile organic compounds. Upon completing its evaluation, the staff of CARB

notified all air pollution control districts in California that Soil-Sement®'s air quality claims had been verified. As a result of CARB's notification, air pollution control agencies have become familiar with Soil-Sement® and its proven air quality benefits.

CalCert and California Air Resources Board Certification



CALCERT
INNOVATION ASSURED

The California Environmental Technology Certification Program (CalCert), an internationally recognized independent, scientific and engineering evaluator of environmental performance, and the California Air Resources Board (CARB), one of the world's leading advocates of new environmental technologies, have certified Soil-Sement®



performance. These certifications offer users and clients performance assurances when dependability is important and the cost of failure unacceptable.

"When topically applied as a dust suppressant in accordance with manufacturer's instructions, including a total target concentration of 0.28 gallons of concentrate per square yard of treated surface applied in multiple passes in a single day, Soil-Sement® reduced PM₁₀ emissions by approximately 84 percent after 339 days and 6,780 vehicles (predominantly light-duty) passes on an unpaved roadway consisting of a silty, sandy loam.

Soil-Sement® does not contain detectable levels of polynuclear organic matter which includes polynuclear aromatic hydrocarbons as defined by the Federal Clean Air Act section 112 (b); nor does Soil-Sement® contain detectable levels of fluorinated or brominated compounds that could be expected to contribute to ozone depletion or global warming."



For complete Soil-Sement® certification information from CalCert, visit calepa.ca.gov/CalCert/CertifiedTech/Midwest.htm, or from the California ARB, visit www.arb.ca.gov/eqpr/mainlist.htm, or www.soilsement.com.


"Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil-Sement® Dust Suppressant," California Air Resources Board, Executive Order G-096-029-035.

Midwest Industrial Supply, Inc. Receives Canadian Verification Certificate.

The Honorable Christine S. Stewart, Canadian Minister of the Environment, awarded a verification certificate to Midwest Industrial Supply, Inc. under the Environmental Technology Verification (ETV) Program.

The ETV Program promotes the marketability of companies engaged in the environmental industry by providing assessment and validation of suppliers' technology performance. At the same time, it provides buyers with the assurance that the technology in question does indeed perform as claimed.





Environmental Technology Verification Program
— enhancing the credibility of environmental technologies


Soil-Sement®


Midwest Industrial Supply Inc.'s Soil-Sement®, when applied in accordance with the manufacturer's instructions, will:

1. on unpaved roadways in California's San Joaquin Valley
 - a. achieve at least 95% suppressant efficiency on fugitive dust (PM_{10}) for three months after application and at least 80% after 11 months, and
 - b. increase the R-value in the range of 30-40% when measured by ASTM Test Protocols D1883 and D2844, and calculated in accordance with the AASHTO Guide for Design of Pavement Structures, 1986; and
2. in acute toxicity tests, yield LC_{50} 's for rainbow trout (96-hr) and *Daphnia magna* (48-hr) of at least 7,000 ppm and 21,000ppm, respectively.

License Number: ETV 99005
Issued to: Midwest Industrial Supply Inc.

Verified* Performance
March 25, 1999


John McMullen
President & CEO

 canada inc.

Canada IN * Refer to Technology Fact Sheet for additional information on the verification of this performance claim.

The Honorable Christine S. Stewart, Canadian Minister of the Environment presenting Canada Environmental Technology Verification certificate to Robert Vitale, President of Midwest Industrial Supply, Inc.



Why Environmental Technology Verification is Valuable for You and Why Midwest Supports ETV



CALCERT
INNOVATION ASSURED

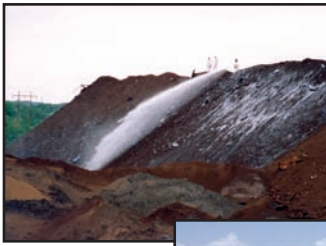
SOIL-SEMENT® TECHNOLOGY CERTIFICATION REQUIRES THAT:

- Significant reduction of PM10 emissions is verified.
- Environmental claims are verified.
- Complete evaluation and review of all test methods and protocols used to assure scientific, statistical accuracy of conclusions.
- Midwest is to continuously meet requirements for product certification to remain valid.
- Midwest can demonstrate having control over the manufacturing of the product to ensure we can consistently and reliably produce product that performs at least as well as the product used in the certification testing. Midwest's quality system is designed to meet the criteria of ISO-9001.
- Midwest quality management practices and standards are reviewed and certified.
- Midwest user manuals and application documents are reviewed and verified.
- Midwest's policy and procedure manual for personnel training of application is reviewed and verified.



*Soil-Sement®'s
Government
Verifications
are a Great Deal More
than Meets the Eye!*

THE MANY USES OF SOIL-SEMENT®



Residual Waste Landfills



Car Topping

Airports FOD



Pond Slopes



Naturally Occurring Asbestos



Intermodal

Hydroseeding

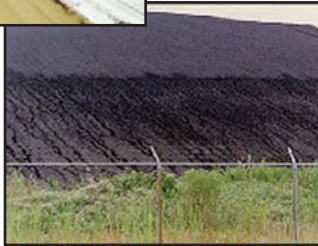


Unpaved Shoulders



Subgrade Stabilization

Coal Piles



Quarries



Public Works

Military Installations



Slopes



Steel Mills



Wineries



Power Plants

COMPLETE REPORTS AND TECHNICAL DATA AVAILABLE UPON REQUEST

For more information or to receive a complete list of other Midwest products, contact:

Midwest Industrial Supply, Inc.
1101 3rd Street Southeast
Canton, Ohio 44707
www.midwestind.com

Tel 330.456.3121
Fax 330.456.3247
Toll Free 1.800.321.0699



Soil-Sement®

SECTION I — IDENTIFICATION OF SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

TRADE NAME:	Soil-Sement®
CHEMICAL NAME:	Polymer Emulsion
SYNONYMS:	Dust Retardant
CHEMICAL FAMILY:	N/A
MOLECULAR WEIGHT:	N/A
FORMULA:	Aqueous Acrylic Vinyl Acetate Polymer Emulsion
CAS REGISTRY NO.:	Product A Blend - No Number Assigned

SECTION II — COMPOSITION/INFORMATION ON INGREDIENTS

NAME	CAS REG NO.	WT. %
Acrylic & Vinyl Acetate Polymer	Non-hazardous	5-50
Water	7732-18-5	95-50

SECTION III — HAZARDS IDENTIFICATION**ACRYLIC & POLYVINYL ACETATE**

POLYMER	Non-hazardous
Water	Non-hazardous

SECTION IV — FIRST AID MEASURES

EYES:	Flush eyes with flowing water at least 15 minutes, get medical attention.
INHALATION:	Move subject to fresh air.
SKIN:	Flush with large amount of water or wash with soap and water.
INGESTION:	Give water to drink. Call a physician
NEVER GIVE FLUIDS OR INDUCE VOMITING. IF PATIENT IS UNCONSCIOUS OR HAVING CONVULSIONS.	

SECTION V — FIRE FIGHTING MEASURES

FLASH POINT (TEST METHOD):	Non-Combustible
AUTOIGNITION TEMPERATURE:	N/A
EXTINGUISHING MEDIUM:	N/A
SPECIAL FIREFIGHTING PROCEDURES:	N/A
UNUSUAL FIRE AND EXPLOSION HAZARDS:	Material can splatter above 212°F. Dried polymer film can burn but will not support combustion.

SECTION VI - ACCIDENTAL RELEASE MEASURES

SPILL AND LEAK PROCEDURES:	Dike and control spill. Transfer liquid to containers for recovery or disposal. Keep spills out of sewers and open bodies of water.
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SECTION VII — HANDLING AND STORAGE

STORAGE:	Keep in a cool, dry, ventilated storage area and in closed containers. Minimize contact with the air to prevent microorganism contamination and reduce the formation of skins on the surface. KEEP FROM FREEZING
HANDLING:	Handle in a well-ventilated workspace.

SECTION VIII — EXPOSURE CONTROL/PERSONAL PROTECTION

RESPIRATORY PROTECTION:	None required if good ventilation is maintained.
VENTILATION:	Mechanical exhaust at point of contaminant.
EYE PROTECTION:	Chemical splash goggles recommended.
PROTECTIVE CLOTHING:	Impervious gloves recommended.
OTHER:	Under normal handling conditions, the risk of exposure to residual monomer is negligible.

SECTION IX — PHYSICAL AND CHEMICAL PROPERTIES

BOILING/MELTING POINT @ 760 mm Hg:	212°F
VAPOR PRESSURE mm Hg @ 20°C:	17
SPECIFIC GRAVITY OR BULK DENSITY:	1.01 to 1.15
SOLUBILITY IN WATER:	Dilutable
APPEARANCE:	Milky White Liquid
ODOR:	Characteristic Acrylic odor
pH:	4.0 to 9.5

SECTION X — STABILITY AND REACTIVITY

STABILITY:	Stable
CHEMICAL INCOMPATIBILITY:	No hazardous reactions are expected to occur under normal industrial conditions.
HAZARDOUS DECOMPOSITION PRODUCTS:	Thermal decomposition in the presence of air may yield carbon monoxide and/or carbon dioxide and water.
HAZARDOUS POLYMERIZATION:	Does not occur
CONDITIONS TO AVOID:	N/A
CORROSIVE TO METAL:	No
OXIDIZER:	No

SECTION XI — TOXICOLOGICAL INFORMATION**EFFECTS OF OVEREXPOSURE**

INHALATION:	Vapor from stored, undiluted product can cause headache and nausea.
SKIN:	Stored, undiluted product is slightly irritating to skin.
EYES:	Slightly irritating to eyes.
INGESTION:	May be irritating to digestive tract.

SECTION XII — ECOLOGICAL INFORMATION

Toxicological evaluation of Soil Sement® utilized EPA methods for both acute and chronic toxicity determination for aquatic organisms. LC50 values were determined for each of the species. The table below contains a synopsis of the results.

SOIL SEMENT AQUATIC TOXICITY TEST RESULT

- Methods for Measuring the Acute Toxicity of Effluents and Receiving Water to Freshwater and Marine Organisms, EPA/600/4-90/027F.
- Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, EPA/600/4-91/002.
- Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms, EPA/600/4-91/003.

SECTION XII — ECOLOGICAL INFORMATION - continued

	Ceriodaphnia dubia	Fathead minnow	Americamysis bahia	Rainbow trout
ACUTE/SURVIVAL (mg/L)				
LC50	>1000	>1000	>1000	320
NOEC	1000	1000	1000	
LOEC	>1000	>1000	>1000	
CHRONIC/SURVIVAL (mg/L)				
LC50	>1000	>1000	>1000	510
NOEC	1000	1000	1000	340
LOEC	>1000	>1000	>1000	700
CHRONIC/GROWTH/ REPRODUCTION (mg/L)				
LC50	>1000	>1000	>1000	540
NOEC	1000	1000	1000	340
LOEC	>1000	>1000	>1000	700

See attached test results:

1. ABC Laboratories, Inc. Americamysis bahia, Fathead minnow, Ceriodaphnia dubia.
2. BAR Invironmental, Inc. Rainbow trout
3. EnviroScience Inc. Rainbow Trout, Chronic (New Data)

LC50 - Lethal Concentration, 50%

NOEC - No Observable Effects Concentration

LOEC - Lowest Observable Effects Concentration

Comparison of the EPA guidelines to the LC50 levels of all species show that Soil Sement® is practically non-toxic to all species.

SECTION XIII — DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD:	Coagulate the emulsion by the stepwise addition of ferric chloride and lime or the addition of sand or other absorbent material. Remove the clear supernatant liquid and flush to a chemical sewer or landfill. Incinerate solids and the contaminated diking material according to local, state and federal regulations.
CONTAINER DISPOSAL:	Do not re-use containers. Do not weld on metal containers.

SECTION XIV — TRANSPORTATION INFORMATION

D.O.T. PROPER SHIPPING NAME (49CFR172.101):	None
HAZARDOUS SUBSTANCE (40CFR116):	N/A
REPORTABLE QUANTITY (RQ):	N/A
D.O.T. HAZARD CLASSIFICATION (49CFR172.101):	Non-regulated
D.O.T. PLACARDS REQUIRED:	None
POISON CONSTITUENT (49CFR173.343):	N/A
BILL OF LADING DESCRIPTION:	Liquid plastic, NOS
C NO.:	N/A
UN/NA CODE:	N/A

SECTION XV — REGULATORY INFORMATION

SOIL-SEMENT® is not a restricted article according to the Department of Transportation and International Air Transport Association regulations.

EPA SARA Title III hazard class:	None
OSHA HCS hazard class:	Non-OSHA hazardous (29CFR1910.1200)

Toxic Chemicals present in quantities greater than the "de minimus" level are: None
TSCA:

All ingredients are on the TSCA (Toxic Substance Control Act) inventory or are not required to be listed on the TSCA inventory.

California Proposition 65: This product contains no trace amount of chemical(s) known to the state of California to cause cancer or birth defects.

Canadian DSL: All ingredients are in the Canadian DSL (Domestic Substance List) or are not required to be on the list.

Canadian WHMIS: This product is not a "controlled product" under the Canadian Workplace Hazardous Material Information System (WHMIS)

SECTION XVI — OTHER INFORMATION

ABBREVIATIONS AND SYMBOLS:	N.D. - Not Determined
	N.A. - Not Applicable
	N.T. - Not Tested
	< - Less Than
	> - Greater Than

Midwest Industrial Supply, Inc.
1101 3rd Street Southeast
Canton, Ohio 44711
www.midwestind.com

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Fax 330.456.3247
Emergency Phone Number 1.800.321.0699

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Midwest Industrial Supply Inc.

Subject: Phone conversation between Frank Elswick, Midwest Industrial Supply Inc., and Margaret Heaphy, North Fork Landowners' Association Road Committee.

Date: January 16, 2009

I contacted Midwest Industrial Supply Inc. after learning the company has some "environmentally friendly" products on the market for dust abatement.

After briefly describing the North Fork Road situation, Frank suggested two products: **Soil Sement** and **Road Oyl**. It depends on the road base but he felt one of these two would meet our needs. Soil Sement is environmentally certified and used by BLM, military, Fish and Game. Road OYL is a modified resin and also used by various agencies.

If the road is stable and not falling apart in places, after grading, the product can be applied. Most likely apply yearly in spring or summer. The products need a lot of fines in the road bed to get strength and bind up particles. This product should reduce potholes and give relief from maintenance. The intent is to try to keep as much moisture out of the road bed as possible. There will be residual benefits each year.

When asked about **Envirokleen** (which is used in Alaska), he said it doesn't bind particles but just does dust control. He said the cost would be much higher. The advantage is it can be applied in any temperature, which is needed in Alaska. These other products need to be applied when temps are above 32 degrees.

COST:

Soil Sement or Road Oyl treatment: These two are the same cost. To do everything including getting the material to us and applying would be 13-15 cents per square foot. On a 24- to 28-foot road that translates to \$17,700 per mile applied. This price is based on \$7/gallon. Envirokleen is 23 to 25 cents per square foot.

When asked how much it would cost to apply it ourselves, he said it depends on how they ship the Soil Sement or Road Oyl.

55-gallon drums cost \$6.62/gallon to ship
275-gallon totes are an option
A 5,000-gallon load is least expensive at \$4.50/gallon

To do the bulk delivery he said you need to have a 5,000-gallon tank. Anything that holds water will hold either product. He said a 5,000-gallon poly tanks can be bought for \$1,000 or so. When asked about applying he said we would need 2,500 gallons per mile. (I believe this is based on a 24-foot-wide road surface).

APPLICATION:

All that's needed is a spray bar mounted on a water truck. To clean the application truck it needs to be washed out right away, the same day as applied. He said one gallon for 50 square feet will be three coats. The first coat would soak in immediately. Third would be longer to saturate. If it does get on a car it takes elbow grease to get off. Must keep traffic off and only do one side of road at a time. And never work on more than 1/2 mile at a time.

He said they can sell the products in a 5-gallon bucket to compare. He said when the product is applied it is diluted at that time. There must be a water source available. He said Envirokleen is not diluted but is sprayed straight.

The company is doing everything now from an environmental perspective. It has been around for over 30 years. It used to purvey chloride products but stopped using them 10 years ago. He said they are detrimental to streams and waterways. He also said it kills vegetation. It will leach with rain and can get slick. Basically they are saltwater products. Sodium builds up in the road bed. It pulls moisture out of the air.

His contact information:

Frank Elswick

Office: (805) 937-7157

Cell: (805) 878-2522

frank.elswick@midwestind.com

www.midwestind.com; (800) 321-0699, 8-5 EST

Frank is sending information and a CD in the mail.

CONCLUSION:

At 2,500 gallons per mile and cost of product at \$4.50/gallon it would be \$11,250 per mile just for the product. Then you have to pay to apply. Maybe spraying a 20-foot-wide swath rather than a 24 foot wide swath would reduce costs if that is practical.

###

Soybean-Oil Byproduct based Dust Suppressants



SEARCH FOR A PRODUCT

CONSUMER PRODUCTS

INGREDIENTS AND INTERMEDIATES

INDUSTRIAL PRODUCTS

- Adhesives
- Agricultural Adjuvants
- Carpet Backings
- Dielectric Fluids/Coolants
- Dust Suppressants
- Hydraulic Fluids
- Industrial Cleaners
- Industrial Coatings
- Industrial Lubricants
- Industrial Solvents
- Metalworking Fluids
- Odor Reduction
- Paint Strippers
- Printing Inks
- Printing Supplies
- Surfacing Agents

COMPANY LISTINGS

Dust Suppressants

BioSpan technologies Inc. (contact info)

P.O. Box 4222
Ballwin, MO 63022
Phone: (800) 730-8980
Fax: (636) 583-1773

<http://www.biospantech.com>
sales@biospantech.com

DeDust® - DeDust® an easy to apply, easy to use nontoxic agent for controlling dust particles. Use current equipment. Biodegradable.

Encapsulate® - Encapsulate® It eliminates most dust by encapsulating the particles which cling to each other. It is biodegradable and safe for its users. Non-reactive to stone, concrete, or organic particles: It will not interfere with asphalt or concrete mixes. Requires no special applicator. Safe on equipment. Works in all temperatures.

Environmental Lubricants Manufacturing (contact info)

5526 Nordic Dr.
Cedar Falls, IA 50613
Phone: 319-277-9075
Fax: 319-277-9078

<http://www.elmusa.com>
laura-schmitt@elmusa.com

DUST SUPPRESSANT - A readily biodegradable, nontoxic dust suppressant and stabilizer. Formulated with natural seed oils and proprietary emulsifiers and surfactants to safely control dust while minimizing the impact on the environment.

✓ SoySolv (contact info)

6154 N. CR 33
Tiffin, OH 44883
Phone: 800-231-4274
Fax: 419-992-4595

<http://www.soysolv.com>
sales@soysolv.com

Steve Smith
8am-12noon, EST

SOYKILL DUST SUPPRESSANT - Provides dust control for a variety of situations, including gravel roads and lots.

Terresolve Technologies (contact info)

35585-G Curtis Blvd.
Eastlake, OH 44095
Phone: 800-661-3558
Fax: 440-951-4341

<http://www.terresolve.com>
memiller@terresolve.com

brochure from website

ENVIROLOGIC 500 - Dust-control concentrate. Can also be used as a concentrate or dilute as a mold and form release oil.

✗ The Solae Company (contact info)

1034 Danforth Dr.
St. Louis, MO 63102
Phone: 800-325-7108

<http://www.thesolaecompany.com>

Jenny Westfall, x3204
"Lethicin Account Manager"

ROADKILL DUST SUPPRESSANT - Dust suppressant.

**SOY-BASED
PRODUCTS
INSIDE:**

Asphalt Release Agents	1
Bar Chain Oil	1
Building Materials	1
Candles	1
Cleaning Solvents	1
Concrete Form Release	1
Crayons	2
Crop Adjuvant	2
Cutting Oils	2
Diesel Fuel Lubricity Additive	2
Dust Suppressants (ie: Roads)	2
Fifth-Wheel Grease	2
Gasoline Additive	2
Gear Box Oils	2
Graffiti Removers	2
Hair Care Products	2
Hand Cleaners	2
Hand Lotions	2
Hydraulic Oils	2
Insulation (Spray Foam)	2
Iron Fertilizer	2
Metal-Working Fluids-Lubes	3
Motor Oils	3
Nail Polish Remover	3
Odor Reducer	3
Oil Spill Cleanup	3
Paint & Paint Removers	3
Penetrants & Lubricants	3
Pumice Hand Cleaners	3
Pump Oils	3
Railroad Flange Lubricants	3
Soy Ink	3
SoyNuts	3
Soy Clothing	3
Tofu Bears	3
Towels & Throws	3
Two-Cycle Engine Oil	3
Wax-Polish	3
Wood & Concrete Sealers	3
Yarn	3

**Supplier/Retailer Contact
Information**

Page 4



Soy-Based Products Supplier/Retailer List



Published by: Michigan Soybean Promotion Committee
PO Box 287, Frankenmuth, MI 48734
Phone: 989.652.3294 or visit www.michigansoybean.org

ASPHALT MILLINGS RESTORER

BioSpan Technologies
Washington, MO

ASPHALT RELEASE AGENTS

Quik Release
Archer Petroleum,
Omaha, NE

SC-Safe-T-Solve
***GEMTEK Products,**
Phoenix, AZ

Bio G-100
Griffin Industries,
Cold Spring, KY

SoySolv
SoySolv Industrial Products,
Tiffin, OH

SoyPOWER
West Central, Ralston, IA

BAR CHAIN OIL

Archer Soy-Safe Bar & Chain Oil
Archer Petroleum, Omaha, NE

Biodegradable Bar & Chain Oil
International Lubricants Inc.,
Seattle, WA

Soy 50 Chain Bar Lubricant
TerraBond Industries, LLC,
Lafayette, LA

EnviroLogic 270, EnviroLogic 268
Terresolve Technologies, Ltd.,
Eastlake, OH

SoyLINK
West Central, Ralston, IA

BUILDING MATERIALS

Environ. BIOFIBER
Environ Biocomposites, LLC,
Mankato, MN

CANDLES

Soybean candles are very popular.
Check with your retailer. Many
scents available at craft shows.

CLEANING SOLVENTS

SoyGold
Ag Environmental Products, LLC,
Lenexa, KS

Kleenease Solvent
Archer Petroleum, Omaha, NE

Cleaning Solvents
Columbus Foods Company,
Chicago, IL

Parts Washer
***Renewable Lubricants, Inc.**
Hartville, OH

Bio Soy Orange
***Renewable Lubricants, Inc.**
Hartville, OH

EZ-Solv, MaxiSolv & SuperSolve
***GEMTEK Products,** Phoenix, AZ

Bio G-100
Griffin Industries, Cold Spring, KY

Safe-T-Solve
Iosso Products, Elk Grove, IL

Eliminator Gun Oil
Iosso Products, Elk Grove, IL

Simple Green
McMaster-Carr Supply Co.,
Elmhurst, IL

Mr. Good Chem
Mr. Good Chem,
Downers Grove, IL

CLEANING SOLVENTS (CONTINUED)

SoyGreen
***Soy Technologies,**
Delray Beach, FL

SOYsolv, SOYsolvII, SOYsolvIII
Plus
SOYsolv Ind. Prods, Tiffin, OH

Soy 30 Agri-synthetic
Degreaser
TerraBond Industries, LLC,
Lafayette, LA

Adhesive Mastic Remover
***SoyClean,** Brooklyn, IA

Barbeque Grill Cleaner
***SoyClean,** Brooklyn, IA

Dry Erase Board Restorer
***SoyClean,** Brooklyn, IA

Hard Surface Stain Remover
***SoyClean,** Brooklyn, IA

Driveway, Sidewalk, & Patio
Cleaner
***SoyClean,** Brooklyn, IA

CONCRETE FORM RELEASE AGENTS

Bio G-100
Griffin Industries,
Cold Spring, KY

MBI Technologies,
Woodburn, IN

SMD-10, SMD-70, SMD-2K &
SMD Form Base
SMD Products Co. Inc.,
Manchester, MO

SoySolv Industrial Products,
Tiffin, OH

Soy Form Release & Natural
Form Oil
***SoyClean,** Brooklyn, IA

<p>CRAYONS</p> <p><u>Prang Fun Pro</u> Kmart, Office Depot, Office Max, Target, Wal-Mart</p>	<p>DIESEL FUEL LUBRICITY ADDITIVE (CONTINUED)</p>	<p>GASOLINE ADDITIVE</p> <p><u>Soy Ultra</u> Schaeffer Mfg. Company, St. Louis, MO</p>	<p>HAND CLEANERS</p> <p><u>Hand & Body Wash</u> *GEMTEK Prod., Phoenix, AZ</p> <p><u>SoyDerm. Industrial Strength</u> *Soy Tech., Delray Beach, FL</p> <p><u>Heavy Duty Hand Cleaner & Moisturizer</u> *SoyClean, Brooklyn, IA</p> <p><u>Hand Sanitizer</u> *Franmar Chem., Normal, IL</p> <p><u>Series 8 Barrier Hand Cream</u> *Franmar Chem., Normal, IL</p>
<p>CROP ADJUVANT</p> <p><u>Soy Crop Oil Concentrate</u> MBI Technologies, Inc., Woodburn, IN</p>	<p><u>#2 Chassis Lubricant—BIO 180 Higher Temp</u> *Renewable Lubricants, Inc., Hartville, OH</p> <p><u>BioPower Diesel Fuel Conditioner</u> *Renewable Lubricants, Inc., Hartville, OH</p> <p><u>SoyShield & SoyShield Winter</u> Schaeffer Manufacturing Co., St. Louis, MO</p> <p><u>Diesel Fuel Additive</u> West Central, Ralston, IA</p> <p><u>Diesel Fuel Additive</u> *SoyClean, Brooklyn, IA</p> <p><u>Bio-Direct</u> Green Diesel, Grand Rapids, MI</p>	<p>GEAR BOX OILS</p> <p><u>Bio Gear Oil</u> *GEMTEK Products, Phoenix, AZ</p>	
<p>CUTTING OILS</p> <p><u>TDE Water Soluble Cutting Fluid</u> *GEMTEK Products, Phoenix, AZ</p> <p><u>Machine Tool Coolant</u> Popelar Filter Co. Inc., Britton, MI</p> <p><u>BIO-TAP</u> International Lubricants, Inc., Seattle, WA</p>	<p>DUST SUPPRESSANTS</p> <p><u>ROADKILL</u> Central Soya, Inc., Fort Wayne, IN</p> <p>SC-1000 *GEMTEK Products, Phoenix, AZ</p> <p><u>SMD Dust Suppressant</u> SMD Products Company, Inc., Manchester, MO</p> <p><u>SOYsolv SOYKILL Dust Suppressant</u> SOYsolv Industrial Products, Tiffin, OH</p> <p><u>Soy Dust Cap</u> TerraBond Industries, LLC, Lafayette, LA</p>	<p>GRAFFITI REMOVERS</p> <p><u>Soy Gold 1000-2000</u> Ag Environmental Products, Lenexa, KS</p> <p><u>Archer Graffiti Remover</u> Archer Petroleum, Omaha, NE</p> <p><u>BEAN-e-doo.</u> *Franmar Chem. Inc., Normal, IL</p> <p><u>SC-Graffiti Remover</u> *GEMTEK Prod., Phoenix, AZ</p> <p><u>Bio G-100</u> Griffin Ind., Cold Spring, KY</p> <p><u>Soy Based Graffiti Remover</u> Mr. Good Chem, Downers Grove, IL</p> <p><u>SOYsolv Graffiti Remover</u> SOYsolv Industrial Products, Tiffin, OH</p> <p><u>SoyPOWER Graffiti Remover</u> West Central Soy, Ralston, IA</p> <p><u>Graffiti Remover</u> *SoyClean, Brooklyn, IA</p>	<p>HAND LOTIONS</p> <p><u>Soy Smooth</u> *Franmar Chemical, Inc., Normal, IL</p> <p><u>Hand & Body Lotion</u> *GEMTEK Products, Phoenix, AZ</p> <p><u>SoySoft Moisturizing Body Lotion.</u> <u>Deep Treatment Penetrating Crème</u> SoySoft, Inc., Edina, MN</p>
<p>DIESEL FUEL LUBRICITY ADDITIVE</p> <p><u>Soy Gold</u> Ag Environmental Products, Lenexa, KS</p> <p><u>Archer Soy Guard. Plus</u> Archer Petroleum, Omaha, NE</p> <p><u>SoyBlend</u> Forward Corporation, Standish, MI</p> <p><u>Bio G-3000</u> Griffin Industries, Cold Spring, KY</p> <p><u>Biodiesel Additive</u> MBI Technologies, Inc. Woodburn, IN</p>	<p>FIFTH WHEEL GREASE</p> <p><u>SoyTRUK</u> West Central, Ralston, IA</p>	<p>HAIR CARE PRODUCTS</p> <p><u>Adult, Pet, & Children's Shampoos</u> *GEMTEK Products, Phoenix, AZ</p> <p><u>Soya System (Shampoos, Conditioners, Styling Aids)</u> Soya System, Mt. Carmel, IL</p>	<p>HYDRAULIC OILS</p> <p><u>BIO Hydraulic Fluid</u> *GEMTEK Products, Phoenix, AZ</p> <p><u>BioSOY Hydraulic Oil</u> West Central, Ralston, IA</p> <p><u>BioSoy All-Season Hydraulic Fluid</u> *SoyClean, Brooklyn, IA</p> <p><u>Envirolift Elevator Oil</u> *SoyClean, Brooklyn, IA</p> <p><u>Food-Grade Hydraulic Fluid</u> *SoyClean, Brooklyn, IA</p> <p><u>BioSoy All Season Hydraulic Oil</u> Spartan Oil, Lansing, MI</p>
			<p>SPRAY FOAM INSULATION</p> <p><u>Healthy Seal</u> Healthy Built Technologies, Hardeeville, SC</p> <p>LAWN FERTILIZER</p> <p><u>LBE</u> Organic Biotech, Springfield,</p> <p><u>Clean Green</u> Practical Soy, Dexter, MI</p>

<p>Agriliance Mark Schoenfeld 51.451.5268</p> <p>SoyGold Bill Ayres 913.599.6911 www.soygold.com</p> <p>American Health & Nutrition 734.677.5570 www.neworganics.com</p> <p>Archer Petroleum Doug Salmon 402.597.8889 archer@archeroil.com www.archeroil.com</p> <p>Baby Center 866.710.2229 www.babycenter.com</p> <p>Baby Soy 888.769.7638 www.babysoyusa.com</p> <p>Bi-O-Kleen Industries 800.477.0188 www.biokleenhome.com</p> <p>BioSpan Technologies 800.730.8980 636.583.1773 www.biospantech.com</p> <p>Our Oaks Farm LLC Tom Bloomer 734.995.0859 tbloomer@umich.edu www.buroaksfarm.com</p> <p>Central Soya, Inc. 219.425.5724 dstroyer@us.cerealworld.com www.centralsoya.com</p> <p>*City Knits 313.872.9665</p> <p>Columbus Foods Co 773.265.6500 jloveshe@columbusfoods.com www.columbusfoods.com</p> <p>Cute Little Clothes 866.511.6256 www.cutelittleclothes.com</p>	<p>Cyndi Waldron & Assoc. Linda Wilkinson 616.530.2700 www.cyndiwaldron.com</p> <p>CytoCulture Environmental Biotechnology Randall von Wedel 510.233.0102 rvw@cytoculture.com www.cytoculture.com</p> <p>Deere & Company Call a John Deere dealer 309.765.8000 www.deere.com</p> <p>Eco Safety Products John Bennett 877.366.7547 or 602.305.9397 ecosafetyproducts.com</p> <p>Environ Biocomposites Krista McCarthy 800.324.8187 507.388.3434 Ext. 519 sales@environbiocomposites.com www.environbiocomposites.com</p> <p>Environmental Lubricants Man. 319.277.9075 www.elmusa.com</p> <p>Flint Ink 734.622.6000 www.flintgrp.com</p> <p>*Franmar Chemical, Inc. Frank Sliney 800.538.5069 franmar@franmar.com www.franmar.com</p> <p>Forward Corporation 989.846.4501</p> <p>*GEMTEK Products Kim Kristoff 800.331.7022 or 602.265.8586 info@gemtek.com www.gemtek.com</p> <p>Green Diesel, Inc. Joe Helgert 616-791-2091 www.green-diesel-inc.com</p>	<p>Griffin Industries Hart Moore 800.743.7413 jhmoore@griffinind.com www.griffinind.com</p> <p>Healthy Built Technologies Mr. Suttle 843.757.2527 www.healthybuilt.com</p> <p>International Lubricants John Nagel 800.333.5823 (LUBE) or 206.762.5343 john@lubegard.com www.lubegard.com</p> <p>Iosso Products Marianne 888.747.4332 iossoproducts@iosso.com www.iosso.com</p> <p>JM Promotions Judy Mettler, 507.387.5887 judyme@hickorytech.net</p> <p>Land O'Lakes Farmland Feed Mark Schoenfeld 651.451.5268</p> <p>Little Red School House Yarn Shop Linda Largent 517.321.6701 lrsh2000@yahoo.com www.lrshyarn.com</p> <p>MBI Technologies, Inc. Don Lightcap 260.632.4003 www.mbitechnologies.com</p> <p>McMaster-Carr Sup. Co. 630.833.0300 Chi.sales@mcmaster.com www.mcmaster.com</p> <p>Mr. Good Chem 800.505.5176 mrgoodchem@aol.com www.mrgoodchem.com</p> <p>National Soy Ink Information Center 515.251.8640 www.soyink.com</p> <p>Nature's Broom Boyd Eifling 662.839.6927 www.natures-broom.com</p>	<p>NatureStain Company Matt Thometz 480.303.8379 www.naturestain.com</p> <p>NMW, Inc. Jim Miller 800.253.4237/317.898.0292</p> <p>Organic Biotech Enrique Urioste 571.237.7873 eurioste@use.net</p> <p>Popelar Filter Co., Inc. Frank Popelar 517.451.8136 pfilter.2000@yahoo.com</p> <p>Practical Soy Jeff Bristle 734.994.5726 practicalsoy@yahoo.com</p> <p>PRC Technologies Rick Greenlaw 888.640.0062 ext. 101 www.rickg@soyprint.net</p> <p>*Renewable Lubricants, Inc. 330.877.9982 www.renewablelube.com</p> <p>Revival Soy 800.738.4825 nutrition@revivalsoy.com www.revivalsoy.com</p> <p>Rosewood Products 734.665.2222 734.668.8430 www.rosewoodproducts.com</p> <p>SMD Products Co., Inc. 636.527.3541 smd_inti@yhb.att.ne.jp</p> <p>Schaeffer Mfg Company Phil Hamilton 800.325.9962 or 314.865.4100 schfrpjh@hotmail.com www.schaefferoil.com</p> <p>South West Trading Co. 866.794.1818 Fax: 480.894.1919 info@tofubear.com www.soy silk.com</p> <p>*SoyClean Kurt Brannian 641-522-9559 rusty@soyclean.biz www.soyclean.biz</p>	<p>*Soy Technologies Bob Denton 800.SOY.8748 info@soytek.com www.soytek.com</p> <p>Soya System Jean Raber Associates 618.298.2050</p> <p>SoySafe Products Inc. 866.359.9401 www.soysafe.com</p> <p>SoySoft, Inc. Lucy or Cliff Larson 800.668.2262 soysoft@aol.com www.SoySoft.com</p> <p>SOYsolv Industrial Products Steve Smith 800.231.4274 sales@soysolv.com www.soysolv.com</p> <p>Soystore.com sales@soystore.com www.soystore.com</p> <p>Spartan Oil Corp. 800.968.OILS jpoole@spartanoilcorp.com</p> <p>TerraBond Industries, LLC David Trahan 888.356.7847 Ext. 21 or 337.291.2778 www.terrabond.net</p> <p>Terresolve Technologies, Ltd. Mark Miller 800.661.3558 or 440.951.8633 memiller@terresolve.com www.terresolve.com</p> <p>*Thread Bear Fiber Arts Studio 517.703.9276</p> <p>US Ink 201.935.8666 www.usink.com</p> <p>West Central 800.843.4769 Bev Tierney 712.667.3340 bev@westcentral.net www.soypower.net</p>
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MSPC

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*** Qualifies as either a small and/or minority owned and/or gender owned and/or veteran owned business.**

Disclaimer: The Michigan Soybean Promotion Committee can in no way be held responsible for any unintentional misrepresentation of products contained here-in. Many product names may be registered or trademark names of the companies listed. This brochure is provided as a service and for informational purposes only.

FLATHEAD COUNTY ROAD & BRIDGE DEPARTMENT

1249 Willow Glen Drive
Kalispell, MT. 59901
Phone: (406) 758-5790
Fax: (406) 758-5794

Information for the North Fork Road

North Fork Road Traffic Counts

ROAD NAME	TYPE	COUNTER LOCATION	START DATE	END DATE	WEEKLY TOTAL	DAILY AVERAGE
North Fork Rd	G	S of Big Creek	05/20/05	05/26/05	2,006	334
North Fork Rd	P	End of Asphalt	06/14/07	06/18/07	2,534	362
North Fork Rd	G	N of Camas Creek	06/14/07	06/18/07	2,695	385

2007

1. Maintenance Cost from January 1, 2007 – December 31, 2007, is \$ 209,910.05.

This includes Maintenance for Bridges, Right-of-Way, Drainage, Grading, Road Repair and Construction, Signs, Guardrail, Rock Removal, Winter Maintenance, Equipment and Materials.

2. Maintenance Costs, Annual Total, and Seasonal – North Fork Road

2007 Maintenance Costs \$209,910.05

Spring	\$14,469.89	(Apr 1 – May 31)
Summer	\$120,818.66	(Jun 1 – Aug 31)
Fall	\$30,361.19	(Sept 1 – Oct 31)
Winter	\$44,260.31	(Jan 1 – Mar 31, & Nov 1 – Dec 31)

3. Facts and Figures

A. \$15,542 received from North Fork parcels for Road Tax only.

B. \$209,910.05 on North Fork Maintenance

1. \$355 per parcel in North Fork (592 parcels)

2. \$700 per resident in North Fork (“IF” 300 Residents)

Postal Carrier stated deliveries to 115 year round NF residents and 220 NF residents during the summer.

3. \$43.05 per resident per year County wide, (\$2,591,150/60,200 residents = \$43.05)

Note: Not per household or tax bill which was established as approximately \$75.00 a year per household.

4. \$209,910.05 = 8.1 % of total County Road Tax spent on the North Fork Road

5. \$395,483 received from School District 6 parcels for Road Tax only. \$209,910.05 = 53.0 % of total County Road Tax from School District 6 spent on the North Fork Road

C. NF Residents = 0.5 % of total county population outside of City Limits

2006

1. Maintenance Cost from January 1, 2006 – December 31, 2006, is \$ 239,698.93.

This includes Maintenance for Bridges, Right-of-Way, Drainage, Grading, Road Repair, and Construction, Signs, Guardrail, Rock Removal, Winter Maintenance, Equipment and Materials.

2. Maintenance Costs, Annual Total, and Seasonal – North Fork Road

2006 Maintenance Costs \$239,698.93

Spring	\$39,092.28	(Apr 1 – May 31)
Summer	\$18,345.59	(Jun 1 – Aug 31)
Fall	\$98,757.95	(Sep 1 – Oct 31)
Winter	\$83,503.11	(Jan 1 – Mar 31, & Nov 1 – Dec 31)

3. Facts and Figures

A. \$14,371 received from North Fork parcels for Road Tax only.

B. \$239,698.93 on North Fork Maintenance

1. \$405 per parcel in North Fork (592 parcels)

2. \$800 per resident in North Fork (“IF” 300 Residents)

Postal Carrier stated deliveries to 115 year round NF residents and 220 NF residents during the summer.

3. \$36.59 per resident per year County wide, (\$2,202,651/60,200 residents = \$36.59)

Note: Not per household or tax bill which was established as approximately \$75.00 a year per household.

4. \$239,698.93 = 10.9 % of total County Road Tax spent on the North Fork Road.

5. \$360,882 received from School District 6 parcels for Road Tax only. \$239,698.93 = 66.4 % of total County Road Tax from School District 6 spent on the North Fork Road.

C. NF Residents = 0.5 % of total county population outside of City Limits



MICHAEL HANRIEDER

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2130 9th Street West #302
Columbia Falls, MT 59912

406.545.0327 OFFICE
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800.671.9481 TOLL FREE



1-800-671-9481

We were expecting more specific costs for our road, based on the info Lyman Co. asked for.

However, all they sent was this generic form letter & the brochure for Cohorex (petroleum emulsion).

received 6/28/10

Spring 2010

To Our Valued Customers:

First, we would like to thank all of our customers for continuing to use Lyman Dust Control of Montana. We are excited to tell you about some new changes to our products and services for 2010!

Most important-our prices are lower than 2009-even though our product costs have been increased by our suppliers. And at this time, there are no plans for a Fuel Service Charge, or *F.S.C.*

We have spent all winter working on our equipment to keep it in peak performance. The equipment is looking and running great-we can't wait until you see it!

We have also worked very closely with our suppliers to work on new products and training that will provide superior dust abatement for you, our customers. Our standard product has been reengineered to be longer-lasting and more durable than last year's products.

We proudly use superior environmentally-friendly, recycled, and E.P.A. approved products to control dust throughout the state of Montana.

We have also procured new supply sources for asphalt emulsion, and will continue to offer polymers and other dust control products, depending on your specific needs.

Please be specific in what product you would like applied to your roadway, as prices, roadway preparation, and availability do vary. Please contact us to discuss your options.

We are also changing our preferred application methods for our products. When possible, we would like to treat the area *before* the road is graded and then a final coating will be applied after the road has been crowned. This will be done at no additional cost to you, our customers.

If your roadway or parking lot is not going to be graded or crowned, please let us know when you place your service request. Application methods, products, and your warranty are affected when your roadway is not prepared.

If the county maintains your roadway, Lyman Dust Control will contact your county road office prior to application. If a permit is required, we will file the permit for you.

Lyman Dust Control has a CUSTOMER SATISFACTION that is unrivaled by our competitors!

All of our customers are important to us and we welcome your questions and concerns. Please feel free to contact us any time at **1-800-671-9481**.

We look forward to hearing from you soon and as always, appreciate your business.

Michael Hanrieder

LYMAN DUST CONTROL OF MONTANA



LYMAN DUST CONTROL 6477 HWY 93 SOUTH WHITEFISH MONTANA 59937



DOWFLAKE Calcium Chloride

Flake calcium chloride reduces maintenance costs and helps prevent runoff on unpaved Forest Service Roads

The Copper Creek Forest Service Road is a 20-foot wide, unpaved road located in the Helena National Forest in western Montana. Like other unpaved roads, it has a history of dusting up in the summer and washboarding. In fact, severe washboarding occurs even though the road is bladed, watered, and recompact three times each year.

Due to concerns about ongoing requirements for road maintenance needed to maintain acceptable ride quality and to eliminate excessive sediment runoff from the road into nearby streams, the U.S. Department of Agriculture Forest Service (Region 1 Materials Engineering Section, Missoula, MT) conducted an evaluation of alternate chemical stabilization treatments on the road. Their goal was to identify a method to improve ride quality, reduce dusting and sediment runoff, reduce aggregate loss, and minimize ongoing maintenance.

The Copper Creek road consists of good quality, well-graded, crushed aggregate. Traffic volumes range from 20 to 50 light vehicles per day from mid-May through November. Vehicle speeds are typically greater than 35 miles per hour.

In June 1998, the Forest Service constructed 17 test sections using seven different maintenance techniques (Table 1). Grades in the test sections were approximately 2 percent. Bentonite clay and 77% flake calcium chloride were used as stabilizing agents on eight of the test sections. The treatment methods included traditional blading, watering, and compaction as well as mixing the stabilization agents with the aggregate to a depth of 2.5 inches. The stabilization agents were applied and blended into the aggregate with the use of an in-place processor operated

Table 1. Surface Treatment Methods and Results

Treatment Description ¹	Additional Blade Maintenance Required ²	Road Serviceability/Quality	
		# of Good Weeks	# of Poor Weeks
Traditional blading, watering, & compaction	5	10	44
Mixing 2.5" deep with in-place processor	5	12	42
Bentonite clay mixed 2.5" deep with in-place processor	4	16	38
1.6 lbs/sq yd flake CaCl ₂ on surface for dust abatement	3	19	35
Bentonite clay mixed 2.5" deep with in-place processor plus 1.6 lbs/sq yd flake CaCl ₂ on surface	3	20	34
2.2 lbs/sq yd flake CaCl ₂ mixed 2.5" deep with in-place processor	2	40	14
4.2 lbs/sq yd flake CaCl ₂ mixed 2.5" deep with in-place processor	0	>54	0

¹ All sections were bladed, watered and compacted.
² During a 54-week period (1998 and 1999 seasons)

by Triple Tree Inc., Missoula, MT. The processor is designed to grind native road surfaces to a specified depth and is essential to ensure the product is adequately mixed. Use of dry calcium chloride flake, such as DOWFLAKE[®] calcium chloride, ensures even blending at high application rates of product with one pass of the processor.

Of the treatment methods evaluated, the best performing was the 77% flake calcium chloride applied at a rate of 4.2 lbs/square yard and blended with the in-place processor to a depth of 2.5 inches. This application rate is designed to provide a calcium chloride concentration (100% basis) in the aggregate of approximately 1.3% by weight. After 54 weeks, the section stabilized with calcium chloride still had not required reblading. The other sections all required grading at least twice due to road surface deterioration. When incorporated as a road base stabilizer, calcium chloride has a characteristic ability to attract and

hold moisture at low humidity and high temperatures. This property enables calcium chloride to keep unpaved road surfaces damp and minimize the loss of fines under severe summer conditions. With its strong moisture film and high surface tension, calcium chloride helps bind aggregate particles together. Consequently, unpaved road surfaces remain compact and stable.

Cost Comparison

Although the initial cost per mile of applying calcium chloride at the 4.2 lbs/square yard rate is higher than most of the other treatment options tested in the study (Table 2), a cost comparison based on maintenance of comparable road quality shows this to be the most cost effective option.

From Table 1, the number of poor weeks of road serviceability identified by the Forest Service over a 12-month, post-treatment evaluation period was used to calculate the number

* Trademark of The Dow Chemical Company

Table 2. Cost-Per-Mile Comparison

Treatment Description	Additional Gradings	In-Place Processing	Bentonite Clay (\$100/ton)	Flake Calcium Chloride (\$160/ton)	Total Cost/Mile
Traditional blading, watering, & compaction	6 x \$600 = \$3,600	0	0	0	\$3,600 ³
Mixing 2.5" deep with in-place processor	6 x \$600 = \$3,600	\$640	0	0	\$4,240 ³
Bentonite clay mixed 2.5" deep with in-place processor	5 x \$600 = \$3,000	\$640	\$1,300	0	\$4,940 ³
1.6 lbs/sq yd flake CaCl ₂ on surface for dust abatement	4 x \$600 = \$2,400	0	0	\$1,500	\$3,900
Bentonite clay mixed 2.5" deep with in-place processor plus 1.6 lbs/sq yd flake CaCl ₂ on surface	4 x \$600 = \$2,400	\$640	\$1,300	\$1,500	\$5,840
2.2 lbs/sq yd flake CaCl ₂ mixed 2.5" deep with in-place processor	3 x \$600 = \$1,800	\$640	0	\$2,100	\$4,540
4.2 lbs/sq yd flake CaCl ₂ mixed 2.5" deep with in-place processor	1 x \$600 = \$600	\$640	0	\$3,900	\$5,140

³ Costs for these treatment sections should be increased by at least \$400/mi to allow for aggregate surfacing replacement since aggregate loss is controlled by flake calcium chloride on other treatment sections.

Table 3. Cost-To Maintain a Smooth Road Surface

Treatment Description	# of Poor Weeks	Treatment Cost/Mile	Cost to Maintain Smooth Road Surface
Traditional blading, watering, & compaction	44	\$3,600	(22 x \$600) + \$3,600 = \$16,800
Mixing 2.5" deep with in-place processor	42	\$4,240	(21 x \$600) + \$4,240 = \$16,840
Bentonite clay mixed 2.5" deep with in-place processor	38	\$4,940	(19 x \$600) + \$4,940 = \$16,340
1.6 lbs/sq yd flake CaCl ₂ on surface for dust abatement	35	\$3,900	(17 x \$600) + \$3,900 = \$14,100
Bentonite clay mixed 2.5" deep with in-place processor plus 1.6 lbs/sq yd flake CaCl ₂ on surface	34	\$5,840	(17 x \$600) + \$5,840 = \$16,040
2.2 lbs/sq yd flake CaCl ₂ mixed 2.5" deep with in-place processor	14	\$4,540	(7 x \$600) + \$4,540 = \$8,740
4.2 lbs/sq yd flake CaCl ₂ mixed 2.5" deep with in-place processor	0	\$5,140	\$5,140

of additional gradings required to maintain a smooth road surface quality. For every two weeks of poor road quality, the cost of one grading was added. For example, if a treatment method resulted in 10 weeks of poor road serviceability, then 5 additional gradings (5 x \$600) would be needed to provide a good quality road surface over the length of the study. These costs were then combined with the total cost per mile from Table 2 to give a more accurate comparison of the cost to provide a smooth road surface with each treatment method. The results of this adjustment are shown in Table 3. When downstream maintenance costs are considered, the 4.2 lbs/square yard flake calcium chloride treatment clearly becomes the most cost-effective option.

Reducing Sediment and Dust

One of the largest sources of sedimentation in rivers, streams, and lakes is surface runoff of fine-grained material from unpaved roads. This sedimentation disrupts fish habitats in nearby waterways. The surface runoff occurs during rainstorms, and it is also caused by snowmelt. The problem is worsened whenever a road is bladed because fine-grained materials are in a loose, vulnerable state. Rain shortly after a blading washes a significant amount of fines to nearby watercourses. According to Bob Griel, an engineering consultant with Triple Tree Inc., "The stabilization of this fine material has the potential to keep thousands of tons of sediment out of streams where bull and brown trout as well as salmon live." As for the elimination of airborne dust from vehicular traffic, a visibility and dust nuisance problem for road users has been virtually eliminated.

Based on the results of this study, the Region 1 Materials Engineering Section has recommended the stabilization of roads with flake calcium chloride where ongoing annual blading is taking place to minimize maintenance costs and reduce environmental impact associated with sedimentation and airborne dust.

In June of 2000, the Forest Service stabilized two additional projects that previously required frequent blading maintenance using flake calcium chloride. The Toll Mountain road east of the Continental Divide near Butte Montana was a short test project similar to Copper Creek. Various calcium chloride flake application rates were blade mixed about 2 inches deep. This project was located in a low humidity area, surfacing material was crushed aggregate and road grades were from 6 to 10 percent. Twelve miles of the Selway River Road in northern Idaho were also treated with five lb/sq. yd of calcium chloride flake to a 3-inch depth with the in-place processor. This road is located in a high humidity area adjacent to the Selway River, the surfacing materials are primarily a native decomposed granitic, and road grades were generally less than 2 percent. Evaluations conducted in November 2000 indicate that both roads provided results similar to the Copper Creek project.

Figure 1. Spreading flake calcium chloride in one of the test sections.



Figure 2. Blending with the in-place processor



Figure 3. Compacting after in-place processing



Figure 4. Grading after in-place processing



For more information, contact The Dow Chemical Company Customer Information Group at 1-800-447-4369 or visit www.dowcalciumchloride.com.

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1 Asphalt Recycling & Reclaiming Association. Full Depth Reclamation - A Century of Advancement for the New Millennium, Annapolis, Maryland: ARRA, January 2001.

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Published February 2004.



Section IV: Dust Control and Stabilization

All gravel roads will give off dust under traffic. After all, they are unpaved roads that typically serve a low volume of traffic, and dust is usually an inherent problem. The amount of dust that a gravel road produces varies greatly. In areas of the country that receive a high amount of moisture, the problem is greatly reduced. Arid or semi-arid regions such as the desert southwest and much of the great plains region in the USA are prone to long periods of dry weather. Similar regions around the globe can have similar weather patterns. Dust can really bring complaints in these areas if there are

residences located near the road and traffic is high.

The quality and type of gravel also has some effect on the amount of dust. Some limestone gravels can dust severely while some glacial deposits of gravel with a portion of highly plastic clay can take on a strong binding characteristic that will resist dusting remarkably well. Still, in prolonged dry weather, there will be dust! Whether to provide some type of dust control or not can be a hard decision to make. Virtually all methods of dust control require annual treatment.

The cost can be prohibitive if traffic volume is low. On the other hand, if traffic is high, the cost of dust control can more than pay for itself with the benefits of reduced material loss and reduced need for blade maintenance. (28) At this point, many agencies will face pressure to pave the road. It may actually be a good economic decision in the long run, especially if there is good indication that traffic will continue to increase in the future. However, never pave a road before it is ready! There is good information on making this decision in Appendix D.

Types of Stabilizers

Chlorides

These are the most commonly used products across the country. They fall into three categories: Calcium Chloride in flake or liquid form, Magnesium Chloride generally in liquid form, and Sodium Chloride (road salt). Sodium is seldom used and is the least effective. Calcium and Magnesium Chloride can be very effective if used properly. They

are hygroscopic products which, in simplest terms, means they draw moisture from the air and keep the road surface constantly damp. They are reasonably simple to use.

Resins

These are products available under various commercial names. The basic composition is lignin sulfonate which is a

by-product of the pulp milling industry. The product is sometimes called "tree sap" in the field. These products work best when incorporated into the surface gravel. They then provide cohesion to bind the soil particles together.

Natural Clays

Some regions of the country have excellent deposits of natural clay that

are highly plastic and provide strong cohesion when added in the right quantity to gravel. However, in prolonged dry weather, these roads will seldom be completely dust free. It can be difficult as well to haul the clay onto the road and mix it into the gravel. Because it is highly plastic, it tends to stick to the truck boxes and requires quite an effort to mix with the gravel.

Asphalts

The use of cut-back liquid asphalts to surface-treat gravel roads was once popular for dust control. However, because of the great amount of fuel oil

or kerosene in these products, they have been banned in many places. Some emulsified asphalts may work for this purpose, but their use is very limited. The product must be applied with special asphalt application equipment.

Soybean Oil

This product is known technically as Acidulated Soybean Oil Soapstock. It is a by-product of the caustic refining process of soybean oil. It is a biodegradable material that has many of the characteristics of a light petroleum-based oil. It will penetrate a gravel surface and provide a light bonding

of the gravel that effectively reduces dust when it is used properly.

Other Commercial Binders

There are too many of these to mention individually. They are marketed under various trade names across the country. It is always wise to try a test section of no more than 1000 feet in length to see how any of these products work with your gravel. One caution: do not use waste products such as crankcase drain oil from engines. This is harmful to the environment and is in violation of EPA rules.

Benefits of Stabilization

Once a road is stabilized there are several benefits. On high volume roads, these benefits can make stabilization very cost effective.

Reduced Dusting

It may be hard to justify the use of any of these products for dust control alone. However, when the products are working well, the added benefit of a stabilized surface that controls the loss of fines through dusting is a great economic benefit. When the fines are lost from a gravel surface, the stone and sand-sized particles that remain will tend to remain loose on the surface, leading to some distresses like washboarding and reduced skid resistance. It will become very hard to maintain. Fresh gravel with a higher percentage of fines needs to be hauled in. This becomes very expensive.

Reduced "Whip Off" of Aggregate

This is another economic bonus to dust control when it is working well. As mentioned earlier, when dust control

products are working well, the fine material in the gravel cannot loosen and dust away. This also means that the stone portion of the gravel will tend to remain embedded in the surface and will not be lost to the edge of the road or even whipped off onto the inslope from heavy traffic. Studies have shown that as much as one ton of aggregate per mile is lost each year for each vehicle that passes over a road daily. This means that a road carrying 200 vehicles per day will experience the loss of 200 tons of aggregate per mile each year. (7) Obviously this will vary with the amount of rainfall received, the quality of the gravel and other factors. Retaining aggregate is a good added benefit to dust control.

Reduced Blade Maintenance

A road surface that remains tightly bound and stable will require much less blade maintenance. The manufacturers of some dust control products highly recommend that the surface should not be bladed at all after their products

are applied. While extra blading, shaping and mixing is needed to prepare a road for dust control, the overall need for blade maintenance should be greatly reduced. This can be a great savings in equipment expense and labor. A county highway official once commented: "I don't react to dust complaints. All gravel roads have dust. But I do react to high maintenance costs. When we have to regrade a road frequently and do blade maintenance frequently, then it's time to look at stabilizing the surface with Magnesium Chloride. Reduced maintenance is what we're after. Dust control is just a bonus!"

Application Tips

There is not enough space to cover application tips for all products. Since the Chlorides are the most commonly used products, we will address the use of those. However, some or all of these tips would apply to the use of most other products as well.

Need for Good Surface Gravel

Keep in mind the Chlorides are not binders. They simply draw moisture from the air. The gravel itself must have a good gradation — particularly a good percentage of fine material with some plasticity. This will give the gravel a natural binding characteristic. The Chlorides then will take over and keep the surface damp and it will remain tightly bound. It will not give up its fines in the form of dust. This point cannot be emphasized enough. If good gravel is not present on the road, it will be wise to haul in good fresh gravel prior to treatment. The cost of the Chloride treatment has been virtually wasted on some roads when the gravel was poor and very short-lived dust control resulted.

Road Preparation

This is another critical point in preparing for dust control treatment. Make sure the road has a good crown in the driving surface. Also, make sure there is good shoulder drainage. Standing water anywhere in the roadway will cause the surface to soften and fail. It will leave a pothole in an otherwise good, stabilized roadway. These can be hard to correct afterwards without disturbing the stabilized surface around it. Another key to preparation is to loosen a minimum of one to two inches of the existing surface and leave it loose at a uniform depth across



The carbide-tipped bits on a cutting edge can be a valuable tool in preparing a road for Chloride treatment. They penetrate the road and give a shallow scarifying effect to loosen and mix the existing gravel. This leaves a nice uniform loose layer of material on the surface.



the roadway. This allows the Chloride to penetrate evenly and quickly into the gravel.

Do not compact the surface at all prior to applying chlorides.

This road has been prepared well for a liquid Magnesium Chloride treatment. Notice the uniform, loose and nicely crowned surface looking over the hilltop. There is also good shoulder drainage as well. This is an excellent example of road preparation.

Applying the Product

The most important need here is for equipment that can be calibrated accurately and that will apply either the liquid or flakes evenly across the surface. Then a good application rate needs to be selected. This will vary with the type of gravel being treated and the length of time dust control is needed. Check with vendors and experts in your area to see what recommended rates are. Next, watch the weather! If rain is forecast or appears to be likely, don't take a chance. Rain on a freshly treated surface will leach out and dilute the Chloride and cause it to run off the road. It can temporarily harm grass on adjacent areas. But the bigger problem will be very poor performance afterwards. Also, it is ideal to keep traffic off of the road for up to two hours after application. This is not always possible, but it is very helpful. It is recommended that one side of the road be treated at a time. Rolling can be helpful, but is not essential. If rollers are used, pneumatic ones are best, and watch to see that the gravel does not start picking up from the surface. If that happens, wait until the surface cures a bit before finishing rolling.



Example of a good piece of application equipment. This truck has a pressurized spray bar with a computerized application system that meters the liquid Chloride with extreme accuracy.



This photo shows part of the spray bar with spraying nozzles.



A very effective, yet simple method of applying flake Chloride accurately with an old farm fertilizer spreader. These machines can be calibrated with great accuracy. Quick cleanup afterward is important since Chloride is corrosive to equipment. Once it is bound in the gravel, corrosive effect on vehicles is very low.

Optimum Moisture

It is important to have the gravel close to optimum moisture just before applying Chlorides. This will cause the product to be absorbed much more quickly and evenly into the gravel. Never apply the Chloride to dry gravel. It will not be evenly absorbed and may show failure in spots.

Test Sections

It is always wise to try a test section of dust control/stabilization treatment if this type of work has not been done before. If there is uncertainty about the suitability of the gravel being used or if there is doubt about the equipment, and/or other products being applied, the process can be tried on a 500-1000 foot road test section. If the process fails at the test section level, then only a small investment and time are lost. Also you have less public complaint.

The outcome from the failed test section will present an opportunity to analyze what may have gone wrong. Another test section can then be tried with a modified process and/or materials. If field performance proves satisfactory, the process can then be applied to larger jobs.



A water truck being used to prewet some very dry gravel just prior to treatment. This dramatically improves the success of the treatment.

United States
Department of
Agriculture

Forest Service

Technology &
Development
Program

7700—Transportation System
2500—Watershed and Air Management
November 1999
9977 1207—SDTDC



Dust Palliative Selection and Application Guide



DUST PALLIATIVE SELECTION AND APPLICATION GUIDE

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November 1999

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ACKNOWLEDGEMENTS

The author would like to first acknowledge all the Forest Service personnel and suppressant manufacturers/suppliers that have shared their wisdom and knowledge on the use of dust suppressants. Acknowledgements should also go to UMA Engineering, George Giummarra, and David Jones, for without their studies and writings, this report would have been much more difficult to pull together.

INTRODUCTION

The purpose of this publication is to help practitioners understand and correctly choose and apply the dust palliative that is appropriate for their particular site, traffic conditions, and climate. In addition, this publication describes the expected performance, limitations, and potential environmental impacts of various palliatives.

This guide examines most of the commonly available dust palliatives currently available and does not endorse any particular product. Since new products will become available and existing products will most likely change following publication of this report, it is recommended that this guide be used as a starting point for determining which palliative would be most appropriate for a given situation.

DUST ABATEMENT BASICS

Dust from unpaved roads is not only a nuisance but creates a safety hazard by reducing the driver's visibility. Dust also affects the health of road users and increases wear-and-tear on vehicles. Dust is always considered an intruder at campsites and picnic areas. In some areas there are regulations that limit the amount of particulate allowed in the atmosphere.

Fine particles, including dust, act to help hold the surface of unpaved roads together. With a loss of fine particles from the roadway, there is an increase in roadway surface raveling and maintenance costs. These fines are smaller than what the eye can see and pass through the 75 μm (No. 200) sieve.

How can dust emissions from the roadway be reduced or eliminated? Since the fines act as a binder that holds the surface of the unpaved road

together, removing them is not a good option. Sealing the surface with an asphalt or concrete pavement or Bituminous Surface Treatment eliminates the dust problem; however, the low traffic on most Forest Service roads does not justify the cost of sealing the road with asphalt, concrete, or a surface treatment. Another alternative is to apply a dust suppressant product. These products are not a permanent solution and will require further applications as the effectiveness of the product decreases with time. Dust suppressants are one of many possible methods to control dust (Foley 1996; UMA 1987; Washington Dept. of Ecology 1996).

Dust suppressants work by either agglomerating the fine particles, adhering/binding the surface particles together, or increasing the density of the road surface material. They reduce the ability of the surface particles to be lifted and suspended by either vehicle tires or wind.

To properly select the appropriate palliative one must understand the primary factors that generate dust. They include the following:

- Vehicle speed
- Number of wheels per vehicle
- Number of vehicles
- Vehicle weight
- Particle size distribution (gradation) of the surface material
- Restraint of the surface fines (compaction, cohesiveness/bonding, durability)
- Surface moisture (humidity, amount of precipitation, amount of evaporation).

An excellent description of these factors that generate dust and how to analyze total long-term costs can be found in Foley et al. (1996) and UMA Engineering (1987).

Selection of the proper dust abatement program must include an understanding of not only the above factors, but the total long-term cost and environmental impacts of that program. Long-term costs include road improvement, road preparation, application of the suppressant in conjunction with the number of times the palliative needs to be applied, and expected change in maintenance practices. Environmental considerations typically

include impacts to the water quality, aquatic habitat, and plant community.

Besides controlling dust, a good dust abatement program may include reduced maintenance bladings and decreased aggregate loss (UMA 1987; Addo and Sanders 1995; Lund 1973).

DUST PALLIATIVE BASICS

There are a wide variety of dust suppressants available on the market today and there will continue to be more in the future. They can be divided into seven basic categories: water, water absorbing products, petroleum based products, organic nonpetroleum based products, electrochemical products, polymer products, and clay additive products. The categories are listed in order based on an estimate of past usage/popularity.

Typical suppressants in each category are:

- Water
- Water Absorbing Products (deliquescent/hygroscopic)
 - calcium chloride brine and flakes
 - magnesium chloride brine
 - sodium chloride (salt)
- Organic Petroleum Products
 - asphalt emulsions
 - cutback asphalt (liquid asphalt)
 - dust oils
 - modified asphalt emulsions
- Organic Nonpetroleum Products
 - animal fats
 - lignosulfonate
 - molasses/sugar beet
 - tall oil emulsions
 - vegetable oils
- Electrochemical Products
 - enzymes
 - ionic products
 - sulfonated oils
- Synthetic Polymer Products
 - polyvinyl acetate
 - vinyl acrylic
- Clay Additives
 - bentonite
 - montmorillonite

Table 1 gives an overview of these seven categories, listing their attributes, limitations, typical application rates, and common names based on Foley et al. (1996), UMA Engineering (1987), TTAO (1986), Bolander (1997), and Scholen (1992). Table 2 lists manufacturers and some distributors of the various dust palliatives.

SUPPRESSANT SELECTION TIPS

To determine the most cost-effective dust palliative, it is recommended that the flow diagram by UMA Engineering (1987) and Washington State Department of Ecology (1996) in figure 1 be followed. Important benefiting factors (Langdon 1980) of dust palliatives that should be considered when evaluating and selecting the proper dust palliative include:

- Cohering the dust particles to themselves or to larger particles
- Resisting wear by traffic
- Remaining on the road
- Resisting aging.

Based on the above characteristics, the product selection chart shown in table 3 should aid in selecting the most suitable dust palliative (Foley et al. 1996; UMA 1987; Bolander 1997; Bolander 1999; Scholen 1992; Langdon et al. 1980; Han 1992). When using the information in table 3, first perform a soils analysis to classify the surface material. Some palliatives require a clay component (plasticity index) or specific amount of fines to properly bind and/or agglomerate. Table 1 provides additional information about dust suppressant limitations, application methods, and environmental impact, which helps further in selecting the best dust palliative. The flow diagram in figure 1 leads the practitioner to figure 2, which is a guide for determining the overall cost of the dust abatement program including the yearly and possibly the multi-year cost of a dust abatement application. Figure 3 is a guide for summarizing the expected benefits of the selected dust control plan.

If a petroleum dust palliative is being considered, further suppressant selection information can be found in Langdon (1980) and Langdon, Hicks, and Williamson (1980).

Table 1—Road dust suppressants.

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Water	<ul style="list-style-type: none"> agglomerates the surface particles normally, readily available 	<ul style="list-style-type: none"> evaporates readily controls dust generally for less than a day generally the most expensive and labor intensive of the inorganic suppressants 	<ul style="list-style-type: none"> frequency depends on temperature and humidity; typically only effective from 1/2 to 12 hours 	<ul style="list-style-type: none"> any potable water source 	<ul style="list-style-type: none"> none
Water Absorbing: Calcium Chloride (deliquescent)	<ul style="list-style-type: none"> ability to absorb water from the air is a function of temperature and relative humidity; for example, at 25°C (77°F) it starts to absorb water at 29% relative humidity, and at 38°C (100°F) it starts to absorb water at 20% relative humidity significantly increases surface tension of water film between particles, helping to slow evaporation and further tighten compacted soil as drying progresses treated road can be regraded and recompacted with less concern for losing moisture and density 	<ul style="list-style-type: none"> requires minimum humidity level to absorb moisture from the air doesn't perform as well as MgCl in long dry spells performs better than MgCl when high humidity is present slightly corrosive to metal, highly to aluminum and its alloys, attracts moisture, thereby prolonging active period for corrosion rainwater tends to leach out highly soluble chlorides if high fines content in treated material, the surface may become slippery when wet effectiveness when less than 20% solution has performance similar to water 	<ul style="list-style-type: none"> generally 1 to 2 treatments per season initial application: <u>flake</u>: @ 0.5 to 1.1 kg/m² (1.0 to 2.0 lb/y²), typical application 0.9 kg/m² (1.7 lb/y²) @ 77% purity <u>liquid</u>: 35 to 38% residual @ 0.9 to 1.6 L/m² (0.2 to 0.35 g/y²), typical application is 38% residual concentrate applied undiluted @ 1.6 L/m² (0.35 g/y²) follow-up: apply @ 1/2 to 1/3 initial dosage 	<ul style="list-style-type: none"> by-product in the form of brine from manufacture of sodium carbonate by ammonia-soda process and of bromine from natural brines three forms: <u>flake</u>, or Type I, @ 77 to 80% purity <u>pellet</u>, or Type II, @ 94 to 97% purity <u>clear liquid</u> @ 35 to 38% solids 	<ul style="list-style-type: none"> water quality impact: generally negligible if the proper buffer zone exists between treated area and water fresh water aquatic impact: may develop at chloride concentrations as low as 400 ppm for trout, up to 10,000 ppm for other fish species plant impact: some species susceptible, such as pine, hemlock, poplar, ash, spruce, and maple potential concerns with spills of liquid concentrate

Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Water Absorbing: Magnesium Chloride (deliquescent)	<ul style="list-style-type: none"> • starts to absorb water from the air at 32% relative humidity independent of temperature • more effective than calcium chloride solutions for increasing surface tension, resulting in a very hard road surface when dry • treated road can be regraded and recompacted with less concern for losing moisture and density 	<ul style="list-style-type: none"> • requires minimum humidity level to absorb moisture from the air • more suitable in drier climates • in concentrated solutions, very corrosive to steel (note: some products may contain a corrosive-inhibiting additive); attracts moisture, thereby prolonging active period for corrosion • rainwater tends to leach out highly soluble chlorides • if high fines content in treated material, the surface may become slippery when wet • effectiveness when less than 20% solution has performance similar to water 	<ul style="list-style-type: none"> • generally 1 - 2 treatments per season • initial application: 28 to 35% residual @ 1.4 to 2.3 L/m² (0.30 to 0.5 g/y²), typical application is 30% residual concentrate applied undiluted @ 2.3 L/m² (0.50 g/y²) • follow-up: apply @ 1/2 initial dosage 	<ul style="list-style-type: none"> • occurs naturally as brine (evaporated) 	<ul style="list-style-type: none"> • water quality impact: generally negligible if the proper buffer zone exists between treated area and water • fresh water aquatic impact: may develop at chloride concentrations as low as 400 ppm for trout, up to 10,000 ppm for other fish species • plant impact: some species susceptible such as pine, hemlock, poplar, ash, spruce, and maple • potential concerns with spills
Water Absorbing: Sodium Chloride (hygroscopic)	<ul style="list-style-type: none"> • starts to absorb water from the air at 79% relative humidity independent of temperature • increases surface tension slightly less than calcium chloride 	<ul style="list-style-type: none"> • requires minimum humidity level to absorb moisture from the air • moderately corrosive to steel in dilute solutions • tends not to hold up well as a surface application 	<ul style="list-style-type: none"> • generally 1 - 2 treatments per season • higher dosages than calcium treatment 	<ul style="list-style-type: none"> • occurs naturally as rock salt and brines 	<ul style="list-style-type: none"> • same as calcium chloride

Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Organic Petroleum Products	<ul style="list-style-type: none"> binds and/or agglomerates surface particles because of asphalt adhesive properties serves to waterproof the road 	<ul style="list-style-type: none"> under dry conditions some products may not maintain resilience if too many fines in surface and high in asphaltenes, it can form a crust and fragment under traffic and in wet weather some products are difficult to maintain 	<ul style="list-style-type: none"> generally 1 to 2 treatments per season 0.5 to 4.5 L/m² (0.1 to 1 g/y²) depending on road surface condition, dilution, and product the higher viscosity emulsions are used for the more open-graded surface materials follow-up: apply at reduced initial dosages 	<ul style="list-style-type: none"> cutback asphalt: SC-70 Asphalt emulsion: SS-1, SS-1h, CSS-1, or CSS-1h mixed with 5+ parts water by volume modified asphalt emulsions emulsified oils mineral oils 	<ul style="list-style-type: none"> wide variety of ingredients in these products “used” products are toxic oil in products might be toxic need product specific analysis potential concerns with spills and leaching prior to the product “curing”
Organic Nonpetroleum: Lignin Derivatives	<ul style="list-style-type: none"> binds surface particles together greatly increases dry strength of material under dry conditions retains effectiveness during long dry periods with low humidity with high amounts of clay, it tends to remain slightly plastic permitting reshaping and additional traffic compaction 	<ul style="list-style-type: none"> may cause corrosion of aluminum and its alloys surface binding action may be reduced or completely destroyed by heavy rain, due to solubility of solids in water becomes slippery when wet, brittle when dry difficult to maintain as a hard surface, but can be done under adequate moisture conditions 	<ul style="list-style-type: none"> generally 1 to 2 treatments per season 10 to 25% residual @ 2.3 to 4.5 L/m² (0.5 to 1.0 g/y²), typical application is 50% residual concentrate applied undiluted @ 2.3 L/m² (0.50 g/y²) or 50% residual concentrate applied diluted 1:1 w/water @ 4.5 L/m² (1.0 g/y²) may be advantageous to apply in two applications also comes in powdered form that is mixed 1 kg to 840 liters (1 lb to 100 gallons) of water and then sprayed 	<ul style="list-style-type: none"> water liquor product of sulfite paper making process, contains lignin in solution composition depends on raw materials (mainly wood pulp) and chemicals used to extract cellulose; active constituent is neutralized lignin sulfuric acid containing sugar 	<ul style="list-style-type: none"> water quality impacts: none fresh water aquatic impacts: BOD may be high upon leaching into a small stream plant impacts: none potential concern with spills

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Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Organic Nonpetroleum: Molasses/Sugar Beet Extract	<ul style="list-style-type: none"> provides temporary binding of the surface particles 	<ul style="list-style-type: none"> limited availability 	<ul style="list-style-type: none"> not researched 	<ul style="list-style-type: none"> by-product of the sugar beet processing industry 	<ul style="list-style-type: none"> water quality impact: unknown fresh water aquatic impact: unknown plant impact: unknown, none expected
Organic Nonpetroleum: Tall-Oil Derivatives	<ul style="list-style-type: none"> adheres surface particles together greatly increases dry strength of material under dry conditions 	<ul style="list-style-type: none"> surface binding action may be reduced or completely destroyed by long-term exposure to heavy rain, due to solubility of solids in water difficult to maintain as a hard surface 	<ul style="list-style-type: none"> generally 1 treatment every few years 10 to 20% residual solution @ 1.4 to 4.5 L/m² (0.3 to 1.0 g/y²); typical application is 40 to 50% residual concentrate applied diluted 1:4 w/water @ 2.3 L/m² (0.5 gal/y²) 	<ul style="list-style-type: none"> distilled product of the kraft (sulfate) paper making process 	<ul style="list-style-type: none"> water quality impact: unknown fresh water aquatic impact: unknown plant impact: unknown
Organic Nonpetroleum: Vegetable oils	<ul style="list-style-type: none"> agglomerates the surface particles 	<ul style="list-style-type: none"> limited availability oxidizes rapidly, then becomes brittle 	<ul style="list-style-type: none"> generally 1 treatment per season application rate varies by product, typically 1.1 to 2.3 L/m² (0.25 to 0.50 g/y²) the warmer the product, the faster the penetration follow-up: apply at reduced initial dosages 	<ul style="list-style-type: none"> some products: canola oil, soybean oil, cotton seed oil, and linseed oil 	<ul style="list-style-type: none"> water quality impact: unknown fresh water aquatic impact: some products have been tested and have a low impact plant impact: unknown, none expected

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Table 1—Road dust suppressants (continued).

Dust Suppressant Category	Attributes	Limitations	Application	Origin	Environmental Impact
Electrochemical Derivatives	<ul style="list-style-type: none"> changes characteristics of clay-sized particles generally effective regardless of climatic conditions 	<ul style="list-style-type: none"> performance dependent on fine-clay mineralogy needs time to “set-up,” i.e. react with the clay fraction difficult to maintain if full strengthening reaction occurs limited life span 	<ul style="list-style-type: none"> generally diluted 1 part product to anywhere from 100 to 600 parts water diluted product also used to compact the scarified surface 	<ul style="list-style-type: none"> typical products: sulfonated oils, ammonium chloride enzymes, ionic products 	<ul style="list-style-type: none"> need product specific analysis some products are highly acidic in their undiluted form
Synthetic Polymer Derivatives	<ul style="list-style-type: none"> binds surface particles because of polymer’s adhesive properties 	<ul style="list-style-type: none"> difficult to maintain as a hard surface 	<ul style="list-style-type: none"> generally 1 treatment every few years 5 to 15% residual solution @ 1.4 to 4.5 L/m² (0.3 to 1.0 g/y²); typical application is 40 to 50% residual concentrate applied, diluted 1:9 w/water @ 2.3 L/m² (0.50 gal/y²) 	<ul style="list-style-type: none"> by-product of the adhesive manufacturing process typically 40 to 60% solids 	<ul style="list-style-type: none"> water quality impact: none fresh water aquatic impact: generally low plant impact: none need product specific analysis
Clay Additives	<ul style="list-style-type: none"> agglomerates with fine dust particles generally increases dry strength of material under dry conditions 	<ul style="list-style-type: none"> if high fines content in treated material, the surface may become slippery when wet 	<ul style="list-style-type: none"> generally 1 treatment every 5 years typical application rate is at 1 to 3% by dry weight 	<ul style="list-style-type: none"> mined natural clay deposits 	<ul style="list-style-type: none"> water quality impact: unknown fresh water aquatic impact: none plant impact: none

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Table 2—Suppressant manufacturers.

Suppressant Category		Product Name	Manufacturer or Primary Distributor	Phone Number	Web Site
Water Absorbing	Calcium Chloride	Calcium Chloride Liquid	General Chemical	800-668-0433	www.genchem.com
		Calcium Chloride Flakes	General Chemical	800-668-0433	www.genchem.com
		Dowflake	Dow Chemical	800-447-4369	www.dowcalciumchloride.com
		Liquidow	Dow Chemical	800-447-4369	www.dowcalciumchloride.com
	Magnesium Chloride	DustGard	IMC Salt	913-344-9334	
		Dust-Off	Cargill Salt Division	800-553-7879	
		Chlor-tex	Soil-Tech	702-873-2023	www.soil-tech.com
	Blend of Calcium and Magnesium Chloride	Dust Fyghter	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com
	Sodium Chloride	Morton Salt	Morton International	312-807-2000	
		IMC Salt	IMC Salt	800-323-1641	
Organic Petroleum	Asphalt Emulsion	CSS-1	Any major asphalt supplier		
	Cutback	MC-70	Any major asphalt supplier		
	Dust Oil/Dust Fluids	Fuel Oil	Pacific Northern Industrial Fuels	206-282-4421	
		Duo Prime Oil	Lyondell Petrochemical Co.	800-423-8434	(white mineral oil)
		EnviroKleen	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com (synthetic iso-alkane)
	Modified Asphalt Emulsion	Asphotac	Actin	219-397-5020	
		Coherex	Witco Corp.	800-494-8287	www.witco.com
		DOPE-30	Morgan Emultech, Inc.	530-241-1364	
		PennzSuppress-D	Pennzoil-Quaker State Co.	713-546-4000	www.pennzsuppress.com
		Penetrating Emulsion Primer (PEP)	Koch Asphalt Co.	909-829-0505	www.kochmaterials.com
		Petro Tac	Syntech Products, Inc.	800-537-0288	www.syntechproducts.com
		Road Pro	Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com
	Sandstill	Energy Systems Associates, Inc.	703-503-7873		
Organic Nonpetroleum	Lignosulfonate	DC-22	Dallas Roadway Products, Inc.	800-317-1968	www.dallasroadway.com
		Dustac	Georgia Pacific West, Inc.	360-733-4410	(was Lignosite)
		Dustac-100	Georgia Pacific West, Inc.	360-733-4410	www.gp.com/chemical/ lignosulfonate
		CalBinder	California-Fresno Oil Co.	209-486-0220	www.calfresno.com
		Polybinder	Jim Good Marketing	805-746-3783	
		RB Ultra Plus	Roadbind America Inc.	888-488-4273	www.roadbind.com

Table 2—Suppressant manufacturers (continued).

Suppressant Category	Product Name	Manufacturer or Primary Distributor	Phone Number	Web Site		
	Molassas/Sugar Beet	Dust Down	Amalgamated Sugar Co.	208-733-4104		
	Tall Oil Emulsion	Dust Control E	Pacific Chemicals, Inc./ Lyman Dust Control	604-828-0218 or 800-952-6457		
		Dustrol EX	Pacific Chemicals, Inc / Lyman Dust Control	604-828-0218 or 800-952-6457		
		Road Oyl	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org	
	Vegetable Oils	Soapstock	Kansas Soybean Association Indiana Soybean Association	800-328-7390 800-735-0195		
		Dust Control Agent SS	Greenland Corp.	888-682-6040		
Electro-chemical	Enzymes	Bio Cat 300-1	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org	
		EMCSQUARED	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org	
		Perma-Zyme 11X	The Charbon Group, Inc.	714-593-1034	www.natural-industrial.com	
		UBIX No. 0010	Enzymes Plus, Div of Anderson Affiliates	800-444-7741		
	Ionic	Road Bond EN-1	C.S.S. Technology, Inc.	800-541-3348	www.csstech.com	
		Terrastone	Moorhead Group	831-685-1148	www.terrastone.com	
	Sulfonated Oils	CBR Plus	CBR Plus, Inc. (Canada)	604-684-8072	www.cbrplus.com	
		Condor SS	Earth Sciences Products Corp.	503-678-1216	www.earthscienceproducts.com	
		SA-44 System	Dallas Roadway Products, Inc.	800-317-1968	www.dallasroadway.com	
		Settler	Mantex	800-527-9919		
		TerraBond Clay Stabilizer	Fluid Sciences, LLC	888-356-7847 or 318-264-9448	www.fluidsciences.com	
	Synthetic Polymer Emulsions	Polyvinyl Acetate	Aerospray 70A	Cytec Industries	800-835-9844	www.cytec.com
			Soil Master WR	Enviromental Soil Systems, Inc.	800-368-4115	
		Vinyl Acrylic	Earthbound L	Earth Chem Inc.	970-223-4998	www.earthchem.com
ECO-110			Chem-crete	972-234-8565	www.chem-crete.com/ soilstabilizer.htm	
PolyPavement			PolyPavement Company	323-954-2240	www.polypavement.com	
Liquid Dust Control			Enviroseal Corp.	561-969-0400	www.enviroseal.com	
Marloc			Reclamare Co.	206-824-2385		
Soiloc-D			Hercules Soiloc	800-815-7668		
Soil Seal			Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org	
Soil Sement			Midwestern Industrial Supply, Inc.	800-321-0699	www.midwestind.com	
TerraBond PolySeal		Fluid Sciences, LLC	888-356-7847	www.fluidsciences.com		
Combination of Polymers		Top Shield	Base Seal International, Inc.	800-729-6985	www.baseseal.com	

Table 2—Suppressant manufacturers (continued).

Suppressant Category		Product Name	Manufacturer or Primary Distributor	Phone Number	Web Site
Clay Additives	Bentonite	Central Oregon Bentonite	Central Oregon Bentonite	541-477-3351	
		Pelbon	American Colloid Co.	800-426-5564 or 847-392-4600	www.colloid.com
		Volclay	American Colloid Co.	708-392-4600	www.colloid.com
	Montmorillonite	Stabilite	Soil Stabilization Products Co., Inc.	800-523-9992	www.sspco.org

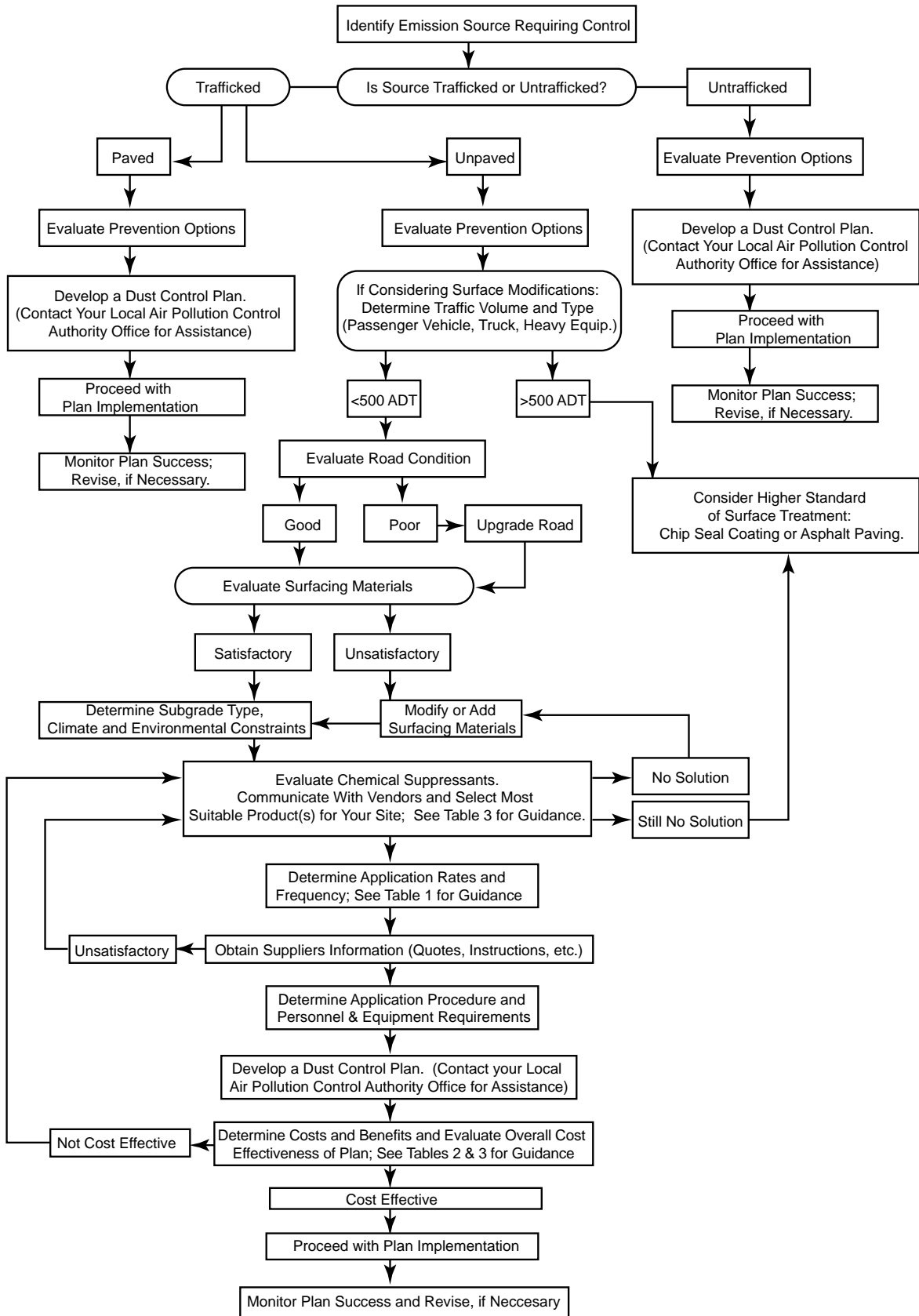


Figure 1—Guidelines for cost-effective selection and use of dust palliatives.

Table 3—Product selection chart.

Dust Palliative	Traffic Volumes, Average Daily Traffic			Surface Material								Climate During Traffic		
	Light <100	Medium 100 to 250	Heavy >250 (1)	Plasticity Index			Fines (Passing 75µm, No. 200, Sieve)					Wet &/or Rainy	Damp to Dry	Dry (2)
				<3	3–8	>8	<5	5–10	10–20	20–30	>30			
Calcium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓	✗ (3)	✗ (3,4)	✓✓	✗
Magnesium Chloride	✓✓	✓✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓	✗ (3)	✗ (3,4)	✓✓	✓
Petroleum	✓	✓	✓	✓✓	✓	✗	✓ (5)	✓	✓	✗ (6)	✗	✓ (3)	✓✓	✓
Lignin	✓✓	✓✓	✓	✗	✓	✓✓ (6)	✗	✓	✓✓	✓✓	✓ (3,6)	✗ (4)	✓✓	✓✓
Tall Oil	✓✓	✓	✗	✓✓	✓	✗	✗	✓	✓✓ (6)	✓ (6)	✗	✓	✓✓	✓✓
Vegetable Oils	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✓
Electro-chemical	✓✓	✓	✓	✗	✓	✓✓	✗	✓	✓✓	✓✓	✓✓	✓ (3,4)	✓	✓
Synthetic Polymers	✓✓	✓	✗	✓✓	✓	✗	✗	✓✓	✓✓ (6)	✗	✗	✓	✓✓	✓✓
Clay Additives (6)	✓✓	✓	✗	✓✓	✓✓	✓	✓✓	✓	✓	✗	✗	✗ (3)	✓	✓✓

Legend

✓✓ = Good ✓ = Fair ✗ = Poor

Notes:

- (1) May require higher or more frequent application rates, especially with high truck volumes
- (2) Greater than 20 days with less than 40% relative humidity
- (3) May become slippery in wet weather
- (4) SS-1 or CSS-1 with only clean, open-graded aggregate
- (6) Road mix for best results

Forest _____ Date _____

Road Name _____ Estimated ADT _____

Road Number _____ Average Road Width _____

Project Location From _____ To _____ Length _____

Dust Palliative Product _____ First Application Rate _____

Second Application Rate _____

Item	Total Cost	Cost/km
A. Road Improvement Costs <ul style="list-style-type: none"> • Drainage improvements • Geometric improvements • Repair of failed areas • Addition of gravel surfacing 		
B. Surface Preparation Costs <ul style="list-style-type: none"> • Addition of select material (fines, etc.) • Break up and loosen, watering, shaping, compacting 		
C. Product Supply and Application Cost <ul style="list-style-type: none"> • Material supply • Diluting with water (if necessary) • Transportation & application 		
D. Miscellaneous Costs <ul style="list-style-type: none"> • Traffic control, detours • Inspection, supervision • Other costs 		
TOTAL COST OF PROGRAM		
COST EXCLUDING ITEM "A" ABOVE		

Figure 2—Cost record for dust control programs.

Forest _____ Date _____

Road Name _____ Estimated ADT _____

Road Number _____ Average Road Width _____

Project Location From _____ To _____ Length _____

Dust Palliative Product _____ First Application Rate _____

Second Application Rate _____

Benefits	Estimated Savings per Year
<p>A. Reduced Maintenance costs</p> <ul style="list-style-type: none"> • Estimate 25 to 75% savings over previous blading costs. Use local figures, if available. 	
<p>B. Reduced Regravelling</p> <ul style="list-style-type: none"> • Estimate based on traffic volume and climate. Use local figures, if available. 	
<p>C. Other (intangible)</p> <ul style="list-style-type: none"> • Reduced vehicle accidents • Reduced vehicle damage • Higher quality of life and property values • Reduced cleaning costs • Reduced dust induced respiratory problems • Reduced sedimentation in water bodies • Reduced impact on dust sensitive vegetation • Reduced complaints from public 	
<p>TOTAL TANGIBLE BENEFITS OF PROGRAM</p>	

Figure 3—Benefits of dust control programs.

SUPPRESSANT APPLICATION TIPS

Once a suitable product is selected, the next step is to determine the appropriate application rate and frequency. Table 1 lists broad ranges of application rates for various products and can be used as a guideline. Manufacturer's literature, past experience, and field or laboratory test plots over a square meter (1 square yard) can also be used to help determine the appropriate application rate.

Generally, higher application rates or increased frequency is required when the following conditions are present:

- High traffic volumes with high speeds and a larger percentage of truck traffic
- Low humidity conditions, especially when using calcium chloride
- Low fines content in road surface, typically when there is less than 10 percent passing through the 75 µm (No. 200) sieve
- Poorly bladed surface and/or loose wearing surface.

General Application Tips

The performance of any dust suppressant is related to many application factors. Application method, rate, frequency, and product concentration are a few of these factors. A stable, tight surface that readily sheds surface water is another. If properly applied and constructed, a longer life and higher level of service can be expected from the dust abatement efforts (Foley et al. 1996; UMA 1987; Washington Dept. of Ecology 1996; Giummarra, Foley, and Cropley 1997). Since dust suppression and road maintenance efforts are usually combined, it is prudent to include the following practices in the maintenance and rehabilitation of road surfaces prior to applying a dust palliative:

- Repair unstable surfacing and/or subgrade areas
- Adequately drain (crown and crossfall) the road surface
- Remove boney (poorly graded) surface material
- Grade sufficient depth of roadway to remove ruts, potholes, and erosion gullies

- Compact the roadway (depending on treatment and sequence of operations).

Maximum benefits can also be achieved by adequate penetration of the liquid dust suppressant. This penetration should be on the order of 10 to 20 millimeters (3/8 to 3/4 inches). Proper penetration mitigates loss of the palliative resulting from surface wear. Adequate penetration also resists leaching, imparts cohesion, and resists aging (Langdon 1980).

Application tips that apply to all liquid dust suppressant products include:

- Apply suppressants, especially salts, immediately following the wet season.
- If possible, apply after rain so materials are moister (aids mixing) and more workable. If applied just before a rain, the material may wash away.
- Adhere to manufacturers' recommendations on minimum application rate, compaction and curing time prior to allowing traffic.
- If the surface material is dry, dampen, except when using cut-back asphalt products.
- If a hard crust is present, break up and loosen the surface.
- Use a pressure distributor to uniformly distribute the dust suppressant.
- Ensure that the necessary "residual" of the product is obtained. The residual is the amount of product that remains after the evaporation of water from the concentrate, as well as that used to dilute the product prior to application. The residual (sometimes called solids or binder) is the portion of the product that is responsible for the binding and/or agglomeration of the particles.

Water Application Tips

Regular, light watering is more effective than less frequent, heavy watering.

Chloride Application Tips

Light compaction is recommended after a chloride brine application.

Petroleum Application Tips

Soil type and density greatly affect the rate and amount of penetration. In all instances, it is desirable to attain a 12 to 25 millimeter (1/2 to 1 inch) penetration. Most products (with the exception of SS- and CSS-1) will penetrate and coat most soils if they have been loosened by scarification. For surfaces which have not been scarified, only those products with low viscosities will penetrate.

Organic Nonpetroleum Application Tips

Remove loose material prior to application unless the road surface will be mixed and/or compacted after the spray application. When applying vegetable oils, the top 25 to 50 millimeter (1 to 2 inches) of the surface should be loose to improve penetration.

Electrochemical Application Tips

Typically these products are mixed into the road surface.

Polymer Application Tips

Light compaction is recommended after a polymer application, unless the polymer is mixed into the road surface.

Clay Additive Application Tips

Ensure that the clay and the associated water used for compaction is uniformly distributed throughout the surface material. This method requires a minimum of 8 passes with a motor-grader or use of a cross-shaft rotary mixer.

All dust suppressants have a limited lifespan and require regular applications to satisfactorily control dust on a long-term basis. Subsequent applications should be made if and when dust levels exceed acceptable levels. These subsequent applications may be lighter than the initial application.

ENVIRONMENTAL IMPACTS

Any suppressant ingredient may migrate due to carelessness in application, run-off, leaching, dust particle migration, or adhesion to vehicles. Carefully review the product literature, Material Safety Data Sheet, and manufacturer's instructions before purchase and use. Observe all safety

precautions and follow manufacturer's directions when handling, mixing, and applying dust suppressants. Application of all dust suppressants must comply with federal, state, and local laws and regulations. These vary by locality and need to be checked prior to implementing the dust abatement program.

The primary environmental concern with dust palliatives is how they impact the groundwater quality, freshwater aquatic environment, and plant community. Take all necessary precautions to keep dust palliative material out of water drainages and roadway ditches leading to streams.

The impact of dust palliatives on groundwater quality is based on how the suppressant migrates to the local groundwater table in conjunction with the chemicals used in the suppressant. Chemical analysis of the suppressant will assist in determining if harmful constituents are present. Knowing the depth to groundwater and the permeability of the native soil will assist in determining how and if the chemicals will leach to the groundwater table. A direct way to evaluate the contamination of harmful constituents to the groundwater is to conduct water quality sampling of the surrounding area before and after dust palliative application.

The impact of dust palliatives on the freshwater aquatic environment is measured by both the toxicity to fish and the availability of oxygen. Each state sets its own standards and they may vary by watershed and the type and age of the fish population. The test to determine toxicity is the LC50 test and the test to determine available oxygen is the BOD (Biochemical Oxygen Demand) test. The LC50 test measures the lethal concentration (LC) of product, expressed in parts per million (ppm), that will produce a 50 percent mortality rate in the test group in 96 hours. The larger the concentration, the less toxic the material. Typically, less than 100 ppm is considered toxic, 1,000 ppm is considered practically nontoxic, and greater than 10,000 ppm is considered nontoxic. The BOD test measures the oxygen used by microbes as it digests (feeds on) the product in water. Typically, the products that are derived from organic nonpetroleum suppressants are the most likely to have high BOD results.

There are no standard tests for measuring how dust palliatives impact the plant community; however, some tests have been performed that simply observe the impact on plant life.

Addo and Sanders (1995) summarize a number of environmental impact studies on the use of various chlorides on water quality, plants, and animals. Heffner (1997) updates the work by Schwendeman (1981) concerning the environmental impacts of some of the most common dust palliatives used by the Forest Service. Based on their efforts, the following is recommended when using these palliatives once or twice a year at their typical application rates:

Lignosulfonate - Determine prior to application if significant migration (water drainage) might occur from the treated area into local streams, ponds, and lakes. Ensure that migration will not impact the oxygen needs of the aquatic community.

Calcium and Magnesium Chlorides - Restrict the use of chlorides within 8 meters (25 feet) of a body of water. In areas of shallow groundwater, determine if significant migration of the chloride would reach the groundwater table. Restrict the use of chlorides if low salt tolerant vegetation is within 8 meters (25 feet) of the treated area. Typical low-tolerant vegetation includes various varieties of alder, hemlock, larch, maple, ornamentals, and pine.

Evaluations of other dust palliatives have not been made. If there is concern regarding the impact of a dust palliative on the environment, then, as a minimum, the LC50 and BOD tests should be performed. Results can be used to estimate the potential impact of the dust palliative in question on the local aquatic and plant communities.

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Library Card

Bolander, Peter, ed. 1999. Dust palliative selection and application guide. Project Report. 9977-1207-SDTDC. San Dimas, CA: U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Center. 20 p.

This publication helps practitioners understand and correctly choose and apply the dust palliative that is appropriate for their particular site, traffic conditions, and climate. Describes the expected performance, limitations, and potential environmental impacts of various palliatives. It is recommended that this guide be used as a starting point for determining which palliative would be most appropriate for a given situation.

Keywords: dust abatement, palliatives, suppressants

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